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APPENDIX.

LIST OF MEMBERS.

	Date of Election.		
Allen, John S., SS. "John MacKay," Halifax	1	Oct.,	1928
Bateson, S., Dalhousie University, Halifax	4	Nov.,	1929
*Bayne, Prof. Parker M., M.A., Acadia University, Wolfville, N. S.	28	Mar.,	1928
Beatty, S. A., B.A., Fisheries Experimental Station (Atlantic), Halifax	4	Nov.,	1929
Bell, Prof. Hugh Philip, Ph.D., Dalhousie University, Halifax	1	Dec.,	1920
Borrett, Major William Coates, Dartmouth, N. S.	26	Feb.,	1925
*Bronson, Prof. Howard L., Ph.D., F.R.S.C., Dalhousie Univ., Halifax	9	Mar.,	1911
Burbidge, Dean George A., Dalhousie University, Halifax	7	Feb.,	1927
*Cameron, Prof. John, M.D., D.Sc., F.R.S.S. E.&C., Dalhousie Univ., Hfx.	2	Nov.,	1915
*Chipman, H. Ritchie, Ph.D., Fisheries Experimental Station (Atlantic) Hfx.	3	Oct.,	1921
Chisholm, H. M., Dalhousie University, Halifax	4	Nov.,	1929
*Colpitt, Parker R., Halifax	2	Feb.,	1903
Copp, Prof. Walter Percy, B.Sc., Dalhousie University, Halifax	28	Apr.,	1921
Cornelia, Bro. Wm. S., St. Mary's Coll., Halifax	1	Oct.	1930
Creighton, Prof. Henry Jermain Maude, D.Sc., F.C.S., Swarthmore, Penn.	7	Jan.,	1908
Cruickshank, Prof. E.W.H., M.D., D.Sc., Ph.D., Dalhousie Univ., Halifax	4	Mar.,	1929
Cunningham, Allen Rupert, M. D., Halifax	1	Dec.,	1921
*Davis, Charles Henry, C. E., New York, N. Y.	5	Dec.,	1900
Dimmitt, R. F., B. A., Dartmouth, N. S.	5	Nov.,	1928
*Doane, Francis William Whitney, City Engineer, Halifax	3	Nov.,	1886
Duchemin, Warren J., B. A , Dalhousie University, Halifax	2	Dec.,	1929
Edwards, George Arnold, M.I.R.E., Halifax	7	Jan.,	1929
Gibbs, Prof. Owen S., M.B., Ch.B., Dalhousie University, Halifax	26	Feb.,	1925
Hall, John C., M.Sc , Harvard University, Cambridge, Mass	4	Feb.,	1929
Hamer, Prof. Richard, Ph.D., Acadia University, Wolfville, N. S.	7	Jan.,	1929
*Henderson, Prof. George Hugh, Ph.D., F.R.S.C., King's College, Halifax	2	Nov.,	1915
Hess, Ernest, M.Sc., McGill University, Montreal, P.Q.	9	Nov.,	1927
Huntsman, Prof. A. G., M.B., F.R.S.C., Univ. of Toronto, Toronto, Ont.	7	Feb.,	1927
Jefferson, W. E., B. Sc., Halifax	3	Dec.,	1928
Johnstone, Prof. John H. L., Ph.D., M.B.E., Dalhousie Univ., Halifax	2	Dec.,	1912
King, Prof. Harold S., Ph.D., Dalhousie University, Halifax	30	Nov.,	1922
King, Mrs. H. S., M. A., Armdale, Halifax	30	Nov.,	1922
Langstroth, George O., M.Sc., McGill University, Montreal	9	Nov.,	1929
Leim, A. H., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	9	Nov.,	1927
McFarlane, A. S., B.S.A., Fisheries Exp. Station (Atlantic)	3	Feb.,	1930
McInnes, Hector, LL.B., K.C., Halifax	27	Nov.,	1889
McIntosh, Prof. Donald Sutherland, M.Sc., Dalhousie Univ., Halifax	9	Mar.,	1911
McIntosh, Prof. Douglas, D.Sc., F.R.S.C., Dalhousie Univ., Halifax	4	Dec.,	1923
*MacKay, George M. Johnstone, M.A., M.Sc., Schenectady, N. Y.	28	Dec.,	1903
*Mackenzie, President A. Stanley, Ph.D., F.R.S.C., Dalhousie Univ., Hfx.	7	Nov.,	1905
Mackenzie, Donald J., M.D., Pathological Institute, Halifax	7	Feb.,	1927
McKnight, Prof. William Ferrier, B.Sc., N.S. Technical College, Halifax	4	May,	1923
Mader, Victor O., M.D., Halifax	7	Feb.,	1927
Marshall, Clyde, M.D., Halifax	4	Mar.,	1929
Marshall, Mrs. Frances B., Ph.D., Halifax	4	Mar.,	1929
Matheson, Donald J., B.Sc., Science Master, Hfx. County Academy, Hfx.	2	Nov.,	1915
Mennie, J. H., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	4	Nov.,	1929
Mitchell, Capt. W. F., Halifax	5	Dec.,	1927
Morton, John McLeod, M.Sc., Princeton University, Princeton, N.J.	30	Jan.,	1928
Murray, Prof. Daniel Alexander, Ph.D., McGill University, Montreal, P.Q.	18	Dec.,	1903
Musgrave, Forrest F., B.A., University of Toronto, Toronto, Ont.	9	Nov.,	1927
*Nicholls, Albert, G., M.D., F.R.S.C., Montreal, P.Q.	2	Nov.,	1915
Nickerson, Prof. Carleton Bell, M.A., Dalhousie University, Halifax	9	Mar.,	1911
Nickerson, J. L., M.A., Princeton University, Princeton, N.J.	7	Feb.,	1927
Piers, Harry, Curator Prov. Museum & Librarian Prov. Science Library, Hfx.	2	Nov.,	1888
*Ritchie, Stephen Galway, B.A., D.M.D., Halifax	3	Oct.,	1918
*Robb. Donald W., Amherst, N. S.	4	Mar.,	1890
Robertson, William G., Halifax	27	Feb.,	1920
Sanborn, J.R., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	4	Nov.,	1929
Sandoz, Georges A., Halifax	26	Feb.,	1925
Schwartz, Hugh W., M.D., Halifax	3	Mar.,	1920
Sexton, Prof. Frederic H., D.Sc., Director of Technical Education, Halifax	18	Dec.,	1903
*Smith, Prof. H. W., B.Sc., Truro, N. S. (Ord. Member, Dec. 1900)	6	Jan.,	1890

Member.

	Date of Election.
Smith, Prof. Ralph P., M.B., C. M. Dalhousie University, Halifax	9 Nov., 1927
*Stewart, Lt. Col. John, M.B., C.M., Dalhousie Univ., Hfx.(Sen. Ord. Mem.)	12 Jan., 1885
Todd, Ebenezer Walter, B A., Dalhousie University, Halifax	27 Nov., 1919
Whyte, Earle Forrester, Ph.D., Halifax	1 Dec., 1920
Wilson, Miss Anna M., M.Sc., Fisheries Experimental Station (Atlantic), Hfx	4 Feb., 1929
*Winfield, James H., Halifax	2 Dec., 1903
*Woodbury, William Weatherspoon, B.Sc., D.D.S., Halifax	30 Nov., 1916
*Yorston, William G., C.E., Halifax	12 Nov., 1892
Young, Prof. Elrid Gordon, Ph.D., Dalhousie University, Halifax	26 Feb., 1925

ASSOCIATE MEMBERS.

*Bigelow, Prof. Henry B., Ph.D., Harvard University, Cambridge, Mass	7 Jan., 1929
Bigelow, Prof. H. E., Ph.D., Mt. Allison University, Sackville, N.B	3 Dec., 1928
Chaisson, Arthur F., Ph.D., St. Francis Xavier Univ., Antigonish, N.S	9 Nov., 1927
*Churchill, Frederick C., Hantsport, N.S	3 Apr., 1919
*Connolly, Prof. C.J., Ph.D., St. Francis Xavier Univ., Antigonish, N.S	5 Nov., 1911
Dentith, Francis Wm. Hubert, B. Sc., Montreal, P.Q	13 Mar., 1922
Fraser, Prof. Roy, B.S.A., M.A., Mt. Allison Univ., Sackville, N. B	7 Jan., 1929
Haley, Prof. Francis Raymond, D.Sc., Acadia University, Wolfville, N.S	5 Nov., 1901
Harlow, Prof. L.C., Ph.D., Agricultural College, Truro, N.S	23 Mar., 1905
Hatcher, Prof. Albert G., M.A., R.C.N. (Retired), Memorial College, St. John's, Nfld	9 Dec., 1914
Hill, Prof. Upton D., Acadia University, Wolfville, N. S	7 Jan., 1929
*MacKay, Hector H., M.D., New Glasgow, N.S	4 Feb., 1902
Munro, Prof. Lloyd A., Ph.D ., University of Manitoba, Winnipeg, Man	1 Nov., 1922
Roscoe, Prof. Muriel V., Ph.D., Acadia University, Wolfville, N.S	7 Jan., 1929
Smith, E.A., Ph.D., Secaucus, N. J	3 Dec., 1925
Tufts, Robie Wilfred, Chief Migratory Bird Officer, Wolfville, N.S	3 Oct., 1921

CORRESPONDING MEMBERS.

Ami, Henry M., D.Sc., F.G.S., F.R.S.C. Ottawa, Ont	2 Jan., 1892
Barbour, Major J. H., R.A.M.C., F.L.S., London, Eng	28 Dec., 1911
Bethune, Rev. Charles J. S., D. C. L., F. R. S. C., Toronto, Ont. (Senior Corresponding Member)	29 Dec. ,1868
Cox, Prof. Philip, Ph.D., University of N. B., Fredericton, N. B	3 Dec., 1902
Dobie, W. Henry, M.D., Chester, England	3 Dec., 1897
Faribault, E. Rudolphe, D. Sc., F. R. S. C., Geol. Survey, Ottawa (Assoc. Member, Mar. 6, 1888)	3 Dec., 1902
Ganong, Prof. William F., Ph.D., Northampton, Mass., U. S. A	6 Jan., 1890
Gates, Reginald Ruggles, Ph. D., F. L. S., London, Eng	30 Nov., 1916
Harris, David Fraser, M.D., D.Sc.), F.R. SS. E. & C., care of Authors' Club, London, England. (Ord. Member, 29 Feb., 1912)	2 Dec., 1924
Matheson, Prof. Robert, Ph.D., Cornell University, Ithica, U. S. A	30 Nov., 1916
Mowbray, Louis L., Director of Miami Aquarium, Miami, Fla	3 May. 1907
Peter, Rev. Brother Junian	12 Dec., 1889
Prichard, Prof. Arthur H. Cooper, Rome, Italy	4 Dec., 1901
Prince, Edward E., LL.D., D.Sc., Ottawa	5 Jan., 1897

*Life Member.

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LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

Hon. Philip Carteret Hill, D. C. L.	31 Dec.	1862	to	26 Oct.	1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct.	1863	"	8 Oct.	1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	9 Oct.	1873	"	9 Oct.	1878
William Gossip	9 Oct.	1878	"	12 Oct.	1880
John Somers, M. D.	13 Oct.	1880	"	26 Oct.	1883
Robert Morrow	26 Oct.	1883	"	21 Oct.	1885
John Somers, M. D.	21 Oct.	1885	"	10 Oct.	1888
Prof. James Gordon MacGregor, M.A., D.Sc., F.R.S., F.R.S.C.	10 Oct.	1888	"	9 Nov.	1891
Martin Murphy, C. E., D. Sc., I. S. O.	9 Nov.	1891	"	8 Nov.	1893
Prof. George Lawson, Ph. D., LL.D., F.I.C., F. R.S. C.	8 Nov.	1893	"	10 Nov.	1895
Edwin Gilpin, Jr., M. A., LL. D., D. Sc., F.G.S., F.R.S.C., I. S. O.	18 Nov.	1895	"	8 Nov.	1899
Alexander McKay, M. A.	8 Nov.	1897	"	20 Nov.	1899
Alexander Howard MacKay, B.A., B.Sc., LL.D., F.R.S.C.	20 Nov.	1899	"	24 Nov.	1902
Henry Skeffington Poole, M.A., D.Sc., A.R.S.M., F.G.S., F. R. S. C.	24 Nov.	1902	"	18 Oct.	1905
Francis William Whitney Doane, C. E.	18 Oct.	1905	"	11 Nov.	1907
Prof. Ebenezer Mackay, Ph. D.	11 Nov.	1907	"	12 Dec.	1910
Watson Lenley Bishop	12 Dec.	1910	"	11 Nov.	1912
Donald MacEachern Fergusson, F. C. S.	11 Nov.	1912	"	12 Oct.	1915
Prof. David Fraser Harris, M. B., C. M., M. D., B. Sc., D. Sc., (London)F. R. SS. E. & C.	13 Oct.	1915	"	18 Nov.	1918
Prof. Howard Logan Bronson, Ph. D., F. R. S. C.	18 Nov.	1918	"	8 Nov.	1920
Prof. John Cameron, M. D., D. Sc., F. R. SS. E. & C.	8 Nov.	1920	"	20 Nov.	1922
Prof. Carleton Bell Nickerson, M. A.	20 Nov.	1922	"	12 Nov.	1924
Stephen Galway Ritchie, B. A., D. M. D.	12 Nov.	1924	"	12 Oct.	1926
Prof. John Hamilton Lane Johnstone, M. Sc., Ph.D., M.B.E.	13 Oct.	1926	"	10 Oct.	1928
Prof. Douglas McIntosh, Ph.D., F.R.S.C.	10 Oct.	1928	"		

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its transactions from 4th January to 3rd December, 1859) led up to the establishment of the Nova Scotian Institute of Natural Science in December, 1862.

Note.—The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 4th March, 1890, the name of the Society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

Since 1879 the Presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

NOTICE TO AUTHORS.

To be printed in the volume of the year, a paper must be submitted for publication on or before the date of the May meeting.

Manuscripts should be typewritten (double spaced) on one side of the paper, 8½x11 inches, with 1 to 1½ inch margins. The original typewritten copy should be furnished.

An abstract, not over 200 words in length, must be placed at the beginning of the article. It should be suitable for reproduction in abstract journals. As an index, it should be complete; all the subjects, major and minor, concerning which new information is presented, should be mentioned. As a summary, the abstract should give briefly the conclusions of the article, important advances in experimental technique and in theory, and numerical results of general interest. For an excellent type of abstract see "The Physical Review." A summary at the end of the article should be omitted since it is included in the abstract.

Citations to the literature and notes will be placed at the bottom of the page and should be indicated in the text by superscript numerals, numbered consecutively from 1 up. All footnotes should be collected on a separate manuscript page for the benefit of the printer. The form of citations should be as indicated by the following examples:

[1]Thomson, *Phil. Mag.*, [7] **3**, 241 (1927).

[2]Bachem, *Arch. exptl. Path. Pharm.*, **122**, 69-76(1927); *C. A.*, **22**, 274 (1928). No reference should be cited which has not been consulted by the author himself. When only an abstract is available, it should be indicated in the citation as in the second case above. In abbreviating journal titles employ standard abbreviations used in such well-known abstract journals as "Chemical Abstracts." In citing books, use the form shown in the following example:

[3]Mellor. "*Inorganic and Theoretical Chemistry,*" Longmans, Green and Co., London. **1923**. vol. 4, pp. 625, 645.

In constructing tables arrange them to leave as little waste space as possible. All drawings intended for reproduction should be made about twice the size of the proposed cut on white paper. They should be drawn with extreme care, preferably by a draftsman. Material in each figure should be arranged compactly. It is well where possible to make the longer dimension horizontal. All lines that are to be reproduced must be sufficiently heavy to be clearly legible in the finished cut. When coordinate paper is used, it should be printed in blue only, with the important lines ruled over in black; the black squares in general should be not less than ten millimeters on a side in the printed cut. The lettering of cuts, when reduced, should be about the size of the letters in the text. Where necessary half-tones for reproduction on special paper will be accepted.

Unless page proofs are specifically asked for galley proofs only are sent to the author for correction. Proofs should be corrected with great care and returned by next mail to the Editor, Dr. Harold S. King, Dalhousie University, Halifax, N. S.

The Institute furnishes the author of each paper with 50 reprints without covers gratis. Additional copies may be obtained at reasonable rates if applied for at the time of return of the proof to the Editor. If covers to reprints are desired, an extra charge is made.

JAN 30 1931

THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

VOLUME XVII, PARTS 1-2-3-4.

SESSIONS 1926-1930.

HALIFAX
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APPENDIX.

LIST OF MEMBERS, 1926-27.

ORDINARY MEMBERS.

	Date of Election.
Allen, E. Chesley, School for the Blind, Halifax	Nov. 28, 1913
Babkin, Prof. Boris, M. D., D. Sc., Dalhousie Univ., Halifax	Feb. 26, 1925
Bagnall, John Stanley, D. D. S., Halifax	Dec. 1, 1921
Bell, Prof. Hugh Philip, M. Sc., Ph. D., Dalhousie University, Halifax	Dec. 1, 1920
Blois, H. Hope, Principal of Bloomfield School, Halifax	Dec. 1, 1921
Borrett, Major William Coates, Dartmouth, N. S.	Feb. 26. 1925
*Bronson, Prof. Howard Logan,, Ph. D., F. R. S. C., Dalhousie, Halifax	Mar. 9, 1911
Burbidge, George A., Dalhousie University, Halifax	Feb. 7, 1927
Cameron, Prof. John, M. D., D. Sc., F. R. SS. E. & C., Dalhousie Univ., Hfx.	Nov. 2, 1915
Chipman, Harry Ritchie, Ph. D., Dalhousie University, Halifax	Oct. 3, 1921
*Colpitt, Parker R., Coburg Road, Halifax	Feb. 2, 1903
Copp, Prof. Walter Percy, B. Sc., Dalhousie University, Halifax	Apr. 28, 1921
Cornelia, Rev. Brother W. B., St. Mary's College, Halifax	Oct. 1, 1925
Creighton, Prof. Henry Jermain Maude, D. Sc., F.C.S., Swarthmore, Penn.	Jan. 7, 1908
Cunningham, Allan Rupert, M. D., Halifax	Dec. 1, 1921
*Davis, Charles Henry, C. E., New York City, U. S. A.	Dec. 5, 1900
Dentith, Francis Wm. Hubert, Armdale, Halifax	Mar. 13, 1922
*Doane, Francis William Whitney, City Engineer, Halifax	Nov. 3, 1886
Dreyer, Prof. N. B., M. R. C. S., Dalhousie University, Halifax	Feb. 26, 1925
Forbes, J. D., Ph. D.. Atlantic Expt. Station for Fisheries, Halifax	Jan. 12, 1926
Forward, Charles C., Dom. Govt. Analyst. Halifax	Jan. 5, 1917
Gibbs, Prof. Owen S., M. B., Ch. B., Dalhousie University, Halifax	Feb. 26, 1925
Gowanloch, Prof. James Nelson, B. Sc., Dalhousie University, Halifax	Dec. 4, 1923
Greig, Arthur W., Halifax	Feb. 26, 1925
Hardy, Prof. W. E., B. Sc., N. S. Technical College, Halifax	Nov. 30, 1922
*Henderson, Prof. Geo. Hugh, B. Sc., Ph. D.	Nov. 2, 1915
Huntsman, A. G., D. Sc., Director Atlantic Exper. Station for Fisheries, Hfx.	Feb. 7, 1927
Johnstone, Prof. John Hamilton Lane, M. Sc., Ph. D., M. B. E., Dalhousie University, Halifax	Dec. 2, 1912
Jost, Arthur Cranston, M. D., Provincial Health Officer, Halifax	June 30, 1924
Laurence, George C., B. Sc., Dalhousie University, Halifax	Dec. 3, 1925
King, Prof. Harold Skinner, B. A., Dalhousie University, Halifax	Nov. 30, 1922
King, Mrs. H. S., Armdale, Halifax	Nov. 30, 1922
McCurdy, H. W., Princetown University, Princetown	Jan. 9, 1922
McInnes, Hector, LL.B., K. C., Halifax	Nov. 27, 1889
McIntosh, Prof. Donald Sutherland, M. Sc., Dalhousie University, Halifax	Mar. 9, 1911
McIntosh, Prof. Douglas, D. Sc., F. R. S. C., Dalhousie University, Halifax	Dec. 4, 1923
*MacKay, Alexander Howard, B. A., B. Sc., LL. D., F. R. S. C., Hon. Colonel, Dartmouth, N. S.	Oct. 11, 1885
*MacKay, George M. Johnstone, M. A., M. Sc., Schenectady, N. Y., U. S. A.	Dec. 28, 1903
*Mackenzie, President Arthur Stanley, Ph. D., F. R. S. C., Dalhousie University Halifax	Nov 7' 1905
Mackenzie, Donald J., M. D., Halifax	Feb. 7, 1927
McKnight, Prof. William Ferrier, N. S., Technical College, Halifax	May 4, 1923
McLatchy, Arthur C., Halifax	Feb. 2, 1922
Mader, Victor O., M. D., Halifax	Feb. 7, 1927
Matheson, Donald J., B.Sc., Science Master, Halifax County Academy, Halifax.	Nov. 2, 1915
Munro, Lloyd, A., M. A., McGill University, Montreal	Nov. 1, 1922
Murray, Prof. Forrest H., Ph. D., Dalhousie University, Halifax	Dec. 4, 1923
*Nicholls, Prof. Albert G., M. D., F. R. S. C., Halifax	Nov. 2, 1915
Nickerson, Prof. Carleton Bell, M.A., Dalhousie University, Halifax	Mar. 9, 1911
Nickerson, J. L., Dalhousie University, Halifax	Feb. 7, 1927
Page, William W., Halifax	Dec. 3, 1925
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax	Nov. 2. 1888
Read, Horace Emmerson, B. A., Halifax	Feb. 13, 1922
Redden, John Keith, Halifax	Mar. 13, 1922
*Ritchie, Stephen Galway, B. A., D. M. D., Halifax	Oct. 3, 1918
*Robb, D. W., Amherst, N. S.	Mar. 4, 1890
Robertson, William G., Halifax	Feb. 26, 1920

*Life Member.

	Date of Election.
Sandoz, Georges A., Halifax	Feb. 26, 1925
Scammell, Harold Lambert, Pictou, N. S.	Nov. 30, 1922
Schwartz, Hugh W., M. D., Halifax	Mar. 3, 1920
Sexton, Prof. Frederic H., D. Sc., Director of Technical Education, Halifax	Dec. 18, 1903
Smith, E. A., Ph. D., Secaucus, N. J., U. S. A.,	Dec. 3, 1925
*Smith, Prof. H. W., B. Sc., Truro, N. S. (Ord. Member, Dec. 1900)	Jan. 6, 1890
*Stewart, Lt. Col. John, M. B., C. M., Halifax (Senior Ordinary Member)	Jan. 12. 1885
Theakston, Prof. Harold Raymond, B. Sc., Dalhousie University, Halifax	Jan. 9, 1922
Todd, Ebenezer Walter, B. A., Dalhousie University, Halifax	No . 27, 1919
Tufts, Robie Wilfred, Wolfville, N. S.	Oct. 3, 1921
Whyte, Earle Forrester, Ph. D., Halifax	Dec. 1, 1920
*Winfield, James H., Mar. Tel. & Tel. Co., Halifax	Dec. 2, 1903
*Woodbury, William Weatherspoon, B. Sc., D. D. S., Halifax	Nov. 30, 1916
*Yorston, William G., C. E., Halifax	Nov. 12, 1892
Young, Prof. Elrid Gordon, Ph. D., Dalhousie University, Halifax	Feb. 26, 1925

ASSOCIATE MEMBERS.

	Date of Election.
Brittain, Prof. William H., B. S. A., Macdonald College, P. Q.	Nov. 2, 1915
Churchill, Frederick C., Los Angles, Cal., U. S. A.	Apr. 3, 1919
*Connolly, Prof. C. J., Ph. D., St. Francis Xavier University, Antigonish, N.S.,	Nov. 5, 1911
Cumming, Principal Melville, B. S. A., LL. D., Agricultural College Truro	Nov. 2, 1915
Harley, Prof. Francis Raymond Acadian University, Wolfville, N. S.	Nov. 5, 1901
Harlow, Prof. L. C., B. Sc., Ph. D., Agricultural College, Truro, N. S.	Mar. 23, 1905
Hatcher, Prof. Albert G., Bishop's College, Lennoxville, P. Q.	Dec. 9, 1914
*MacKay, Hector H., M. D., New Glasgow, N. S.	Feb. 4, 1902
Murray, Prof. Daniel Alexander, Ph. D., McGill University, Montreal	Dec. 18, 1903
Shaw, Prof. Percy J., B. A., Agricultural College, Truro, N. S.	Nov. 2, 1915
Tufts, Robie Wilfred, Wolfville, N. S.	Oct. 3, 1921
Westwood, Lieut. Ralph V., Stratford-on-Avon, England	Dec. 5, 1918

CORRESPONDING MEMBERS.

	Date of Election.
Ami, Henry M., D. Sc., F. G. S., F. R. S. C., Laurier Ave., Ottawa	Jan. 2, 1892
Barbour, Major J. H., R. A. M. C., F. L. S., London, Eng.	Dec. 28, 1911
Bethune, Rev. Charles J. S., D. C. L., F. R. S. C., Toronto, Ont. (Senior Corresponding Member)	Dec. 29, 1868
Cox, Prof. Philip, Ph. D., University of N. B., Fredericton, N. B.	Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England	Dec. 3, 1897
Faribault, E. Rudolphe, D. Sc., F. R. S. C., Geol. Survey, Ottawa (Assoc. Member, Mar. 6, 1888)	Dec. 3, 1902
Ganong, Prof. William F., Ph. D., Northampton, Mass., U. S. A.	Jan. 6, 1890
Gates, Reginald Ruggles, Ph. D., F. L. S., London, Eng.	Nov. 30, 1916
Harris, David Fraser, M. D., B. Sc. (Lond.), F. R. SS. E. & C., The Aggons, Dane Hill, Sussex, England. (Ord. Member, 29 Feb., 1912)	Dec. 2, 1924
Matheson, Prof. Robert, Ph. D., Cornell University, Ithica, U. S. A.	Nov. 30, 1916
Mowbray, Louis L., Director of Miami Aquarium, Miami, Fla.	May. 3, 1907
Peter, Rev. Brother Junian	Dec. 12, 1898
Prichard, Arthur H. Cooper, Rome, Italy	Dec. 4, 1901
Prince, Edward E., LL. D., D. Sc., Commissioner of Fisheries, Ottawa	Jan. 5, 1897

*Life Member.

LIST OF PRESIDENTS

OF THE NOVA SCOTIA INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIA INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863	"	8 Oct. 1873
John Bernard, Gilpin, M. A., M. D., M. R. C. S.	9 Oct. 1873	"	9 Oct. 1878
William Gossip	9 Oct. 1878	"	12 Oct. 1880
John Somers, M. D.	13 Oct. 1880	"	26 Oct. 1883
Robert Morrow	26 Oct. 1883	"	21 Oct. 1885
John Somers, M. D.	21 Oct. 1885	"	10 Oct. 1888
Prof. James Gordon MacGregor, M.A., D.Sc., F.R.S., F.R.S.C.	10 Oct. 1888	"	9 Nov. 1891
Martin Murphy, C. E., D. Sc., I. S. O.	9 Nov. 1891	"	8 Nov. 1893
Prof. George Lawson, Ph. D., LL.D., F.I.C., F. R.S. C.	8 Nov. 1893	"	10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. Sc., F.G.S., F.R.S.C., I. S. O.	18 Nov. 1895	"	8 Nov. 1899
Alexander McKay, M. A.	8 Nov. 1897	"	20 Nov. 1899
Alexander Howard MacKay, B.A., B.Sc., LL.D., F.R.S.C.	20 Nov. 1899	"	24 Nov. 1902
Henry Skeffington, Poole, M.A., D.Sc., A.R.S.M., F.G.S., F. R. S. C.	24 Nov. 1902	"	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905	"	11 Nov. 1907
Prof. Ebenezer Mackay, Ph. D.	11 Nov. 1907	"	12 Dec. 1910
Watson Lenley Bishop	12 Dec. 1910	"	11 Nov. 1912
Donald MacEachern Fergusson, F. C. S.	11 Nov. 1912	"	12 Oct. 1915
Prof. David Fraser Harris, M. B., C. M., M. D., B. Sc., D. Sc., (London)F. R. SS. E. & C.	13 Oct. 1915	"	18 Nov. 1918
Prof. Howard Logan Bronson, Ph. D., F. R. S. C.	18 Nov. 1918	"	8 Nov. 1920
Prof. John Cameron, M. D., D. Sc., F. R. SS. E. & C.	8 Nov. 1920	"	20 Nov. 1922
Prof. Carleton Bell Nickerson, M. A.	20 Nov. 1922	"	12 Nov. 1924
Stephen Galway Ritchie, B. A., D. M. D.	12 Nov. 1924	"	12 Oct. 1926
Prof. John Hamilton Lane Johnstone, M. Sc., Ph.D., M.B.E.	13 Oct. 1926	"	

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its transactions from 4th January to 3rd. December, 1859) led up to the establishment of the Nova Scotian Institute of Natural Science in December, 1862.

Note.—The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st. December, 1862. On 4th March, 1890, the name of the Society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

Since 1879 the Presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

APPENDIX.

LIST OF MEMBERS, 1927-28.

ORDINARY MEMBERS.

	Date of Election.
Adshead, John Geoffrey, B. A., Dalhousie University, Halifax	9 Nov., 1927
Allan, W. S., St. John, N. B.	5 Dec., 1927
Allen, C. R. K., School for the Blind, Halifax	5 Dec., 1913
Babkin, Prof. Boris, M. D., D. Sc., Dalhousie Univ., Halifax	26 Feb., 1925
Bayne, Prof. Parker M., Acadia University, Wolfville, N. S.	28 Mar., 1928
Bell, Prof. Hugh Philip, M. Sc., Ph. D., Dalhousie University, Halifax	1 Dec., 1920
Borrett, Major William Coates, Dartmouth, N. S.	26 Feb.. 1925
*Bronson, Prof. Howard Logan,, Ph. D., F. R. S. C., Dalhousie Univ., Halifax.	9 Mar., 1911
Burbidge, George A., Dalhousie University, Halifax	7 Feb., 1927
*Cameron, Prof. John, M. D., D. Sc., F. R. SS. E.&C., Dalhousie Univ.,Hfx.	2 Nov., 1915
*Chipman, Harry Ritchie, Ph. D., Dalhousie University, Halifax	3, Oct. 1921
*Colpitt, Parker R., Coburg Road, Halifax	2 Feb., 1903
Cooper, Douglas, DeB. P., B. Sc., Dalhousie University, Halifax	9 Nov., 1927
Copp, Prof. Walter Percy, B. Sc., Dalhousie University, Halifax	28 Apr., 1921
Cornelia, Rev. Brother W. B., B.Sc., St. Mary's College, Halifax	1 Oct., 1925
Creighton, Prof. Henry Jermain Maude, D. Sc., F.C.S., Swarthmore, Penn.	7 Jan., 1908
Cunningham, Allan Rupert, M. D., Halifax	1 Dec., 1921
*Davis, Charles Henry, C. E., New York City, U. S. A.	5 Dec., 1900
Dentith, Francis Wm. Hubert, Montreal, P. Q.	13 Mar., 1922
*Doane, Francis William Whitney, City Engineer, Halifax	3 Nov., 1886
Dreyer, Prof. N. B., M. R. C. S., Dalhousie University, Halifax	26 Feb., 1925
Eadie, Prof. George, M. B., Ph. D., Dalhousie University	3 Jan., 1928
Ellis, Miss Marjorie F., B. Sc., Dalhousie University	3 Jan., 1928
Forward, Charles C., Dom. Govt. Analyst. Halifax	5 Jan., 1917
Gibbs, Prof. Owen S., M. B., Ch. B., Dalhousie University, Halifax	26 Feb., 1925
Gowanloch, Prof. James Nelson, B. Sc., Dalhousie University, Halifax	4 Dec., 1923
Grant, Gordon A., B. Sc., Halifax, N. S.	9 Nov., 1927
Greig, Arthur W., Halifax	26 Feb., 1925
Hardy, Prof. W. E., B. Sc., N. S. Technical College, Halifax	30 Nov., 1922
*Henderson, Prof. George Hugh, B. Sc., Ph.D., Dalhousie Univ., Halifax	2 Nov., 1915
Hess, Ernest, Atlantic Expt. Station for Fisheries, Halifax	9 Nov., 1927
Huntsman, A. G., M. B., Director Atlantic Exper. Station for Fisheries, Hfx.	7 Feb., 1927
Jackson, Wilfred J., Ph.D., Dalhousie University, Halifax, N. S.	9 Nov., 1927
Johnstone, Prof. John Hamilton Lane, M. Sc., Ph. D., M. B. E., Dalhousie University, Halifax	2 Dec., 1912
Jost, Arthur Cranston, M. D., Provincial Health Officer, Halifax	30 Jan., 1924
King, Prof. Harold Skinner, B. A., Dalhousie University, Halifax	30 Nov., 1922
King, Mrs. H. S., Armdale, Halifax	30 Nov., 1922
Langstroth, George O., B. A., Dalhousie University, Halifax	9 Nov., 1927
Laurence, George C., B. Sc., Dalhousie University, Halifax	3 Dec., 1925
Leim, Dr. A. H., Atlantic Expt. Station for Fisheries, Halifax	9 Nov., 1927
McInnes, Hector, LL.B., K. C., Halifax	27 Nov., 1889
McIntosh, Prof. Donald Sutherland, M. Sc., Dalhousie University, Halifax	9 Mar., 1911
McIntosh, Prof. Douglas, D. Sc., F. R. S. C., Dalhousie University, Halifax	4 Dec., 1923
*MacKay, Alexander Howard, B. A., B. Sc., LL. D., F. R. S. C., Hon. Colonel, Dartmouth, N. S.	11 Oct., 1885
*MacKay, George M. Johnstone, M. A., M. Sc., Schenectady, N. Y., U. S. A.	28 Dec., 1903
*Mackenzie, President Arthur Stanley, Ph. D., F. R. S. C., Dalhousie University Halifax	7 Nov' 1905
Mackenzie, Donald J., M. D., Halifax	7 Feb., 1927
McKnight, Prof. William Ferrier, N. S., Technical College, Halifax	4 May, 1923
McLatchy, Arthur C., Halifax	2 Feb., 1922
Mader, Victor O., M. D., Halifax	7 Feb., 1927
Matheson, Donald J., B.Sc., Science Master, Halifax County Academy, Halifax.	2 Nov., 1915
Mitchell, Capt. W. F., Halifax	5 Dec., 1927
Moran, William G., B. Sc., Dalhousie University, Halifax	9 Nov., 1927
Morton, John McLeod, M. A., Halifax, N. S.	30 Jan., 1928
Munro, Lloyd, A., M. A., Univ. of Manitoba, Winnipeg	1 Nov., 1922
Musgrave, Forrest F., Dalhousie University, Halifax	9 Nov., 1927
*Nicholls, Prof. Albert G., M. D., F. R. S. C., Montreal, P. Q.	2 Nov., 1915
Nickerson, Prof. Carleton Bell, M.A., Dalhousie University, Halifax	9 Mar., 1911
Nickerson, J. L., Dalhousie University, Halifax	7 Feb., 1927

*Life Member.

	Date of Election.
Page, William W., Halifax	3 Dec., 1925
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax	2 Nov., 1888
Redden, John Keith, Sackville, N. S.	13 Mar., 1922
*Ritchie, Stephen Galway, B. A., D. M. D., Halifax	3 Oct., 1918
*Robb, Donald W., Amherst, N. S.	4 Mar., 1890
Robertson, William G., Halifax	27 Feb., 1920
Sandoz, Georges A., Halifax	26 Feb., 1925
Schwartz, Hugh W., M. D., Halifax	3 Mar., 1920
Sexton, Prof. Frederic H., D. Sc., Director of Technical Education, Halifax	18 Dec., 1903
Smith, E. A., Ph. D., Secaucus, N. J., U. S. A.	3 Dec., 1925
*Smith, Prof. H. W., B. Sc., Truro, N. S. (Ord. Member, Dec. 1900)	6 Jan., 1890
Smith, Prof. Ralph P., M. D., Dalhousie University, Halifax, N. S.	9 Nov., 1927
*Stewart, Lt. Col. John, M. B., C. M., Halifax (Senior Ordinary Member)	12 Jan.. 1885
Theakston, Prof. Harold Raymond, B. Sc., Dalhousie University, Halifax	9 Jan., 1922
Todd, Ebenezer Walter, B. A., Dalhousie University, Halifax	27 Nov., 1919
Whyte, Earle Forrester, Ph. D., Halifax	1 Dec., 1920
*Winfield, James H.	2 Dec., 1903
*Woodbury, William Weatherspoon, B. Sc., D. D. S., Halifax	30 Nov., 1916
*Yorston, William G., C. E., Halifax	12 Nov., 1892
Young, Prof. Elrid Gordon, Ph. D., Dalhousie University, Halifax	26 Feb., 1925

ASSOCIATE MEMBERS.

Chaisson, C.. Harvard University, Cambridge, Mass, U. S. A.	9 Nov., 1927
*Churchill, Frederick C., Hantsport, N. S.	3 Apr., 1919
*Connolly, Prof. C. J., Ph. D., St. Francis Xavier University, Antigonish, N.S..	5 Nov., 1911
Haley, Prof. Francis Raymond Acadian University, Wolfville, N. S.	5 Nov., 1901
Harlow, Prof. L. C., B. Sc., Ph. D., Agricultural College, Truro, N. S.	23 Mar., 1905
Hatcher, Prof. Albert G., Bishop's College, Lennoxville, P. Q.	9 Dec., 1914
*MacKay, Hector H., M. D., New Glasgow, N. S.	4 Feb., 1902
Murray, Prof. Daniel Alexander, Ph. D., McGill University, Montreal, P. Q.	18 Dec., 1903
Tufts, Robie Wilfred, Chief Imigratory Bird Officer, Wolfville, N. S.	3 Oct., 1921
Westwood, Lieut. Ralph V., Stratford-on-Avon, England	5 Dec., 1918

CORRESPONDING MEMBERS.

Ami, Henry M., D. Sc., F. G. S., F. R. S. C., Laurier Ave., Ottawa	2 Jan., 1892
Barbour, Major J. H., R. A. M. C., F. L. S., London, Eng.	28 Dec., 1911
Bethune, Rev. Charles J. S., D. C. L., F. R. S. C., Toronto, Ont. (Senior Corresponding Member)	29 Dec., 1868
Cox, Prof. Philip, Ph. D., University of N. B., Fredericton, N. B.	3 Dec., 1902
Dobie, W. Henry, M. D., Chester, England	3 Dec., 1897
Faribault, E. Rudolphe, D. Sc., F. R. S. C., Geol. Survey, Ottawa (Assoc. Member, Mar. 6, 1888)	3 Dec., 1902
Ganong, Prof. William F., Ph. D., Northampton, Mass., U. S. A.	6 Jan., 1890
Gates, Reginald Ruggles, Ph. D., F. L. S., London, Eng.	30 Nov., 1916
Harris, David Fraser, M. D., B. Sc. (Lond.), F. R. SS. E. & C., care of Authors' Club, London, England. (Ord. Member, 29 Feb., 1912)	2 Dec., 1924
Matheson, Prof. Robert, Ph. D., Cornell University, Ithica, U. S. A.	30 Nov., 1916
Mowbray, Louis L., Director of Miami Aquarium, Miami, Fla.	3 May., 1907
Peter, Rev. Brother Junian	12 Dec., 1889
Prichard, Prof. Arthur H. Cooper, Rome, Italy	4 Dec., 1901
Prince, Edward E., LL. D., D. Sc., Ottawa	5 Jan., 1897

*Life Member.

LIST OF PRESIDENTS

OF THE NOVA SCOTIA INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863	"	8 Oct. 1873
John Bernard, Gilpin, M. A., M. D., M. R. C. S.	9 Oct. 1873	"	9 Oct. 1878
William Gossip	9 Oct. 1878	"	12 Oct. 1880
John Somers, M. D.	13 Oct. 1880	"	26 Oct. 1883
Robert Morrow	26 Oct. 1883	"	21 Oct. 1885
John Somers, M. D.	21 Oct. 1885	"	10 Oct. 1888
Prof. James Gordon MacGregor, M.A., D.Sc., F.R.S., F.R.S.C.	10 Oct. 1888	"	9 Nov. 1891
Martin Murphy, C. E., D. Sc., I. S. O.	9 Nov. 1891	"	8 Nov. 1893
Prof. George Lawson, Ph. D., LL.D., F.I.C., F. R.S. C.	8 Nov. 1893	"	10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. Sc., F.G.S., F.R.S.C., I. S. O.	18 Nov. 1895	"	8 Nov. 1899
Alexander McKay, M. A.	8 Nov. 1897	"	20 Nov. 1899
Alexander Howard MacKay, B.A., B.Sc., LL.D., F.R.S.C.	20 Nov. 1899	"	24 Nov. 1902
Henry Skeffington, Poole, M.A., D.Sc., A.R.S.M., F.G.S., F. R. S. C.	24 Nov. 1902	"	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905	"	11 Nov. 1907
Prof. Ebenezer Mackay, Ph. D.	11 Nov. 1907	"	12 Dec. 1910
Watson Lenley Bishop	12 Dec. 1910	"	11 Nov. 1912
Donald MacEachern Fergusson, F. C. S.	11 Nov. 1912	"	12 Oct. 1915
Prof. David Fraser Harris, M. B., C. M., M. D., B. Sc., D. Sc., (London)F. R. SS. E. & C.	13 Oct. 1915	"	18 Nov. 1918
Prof. Howard Logan Bronson, Ph. D., F. R. S. C.	18 Nov. 1918	"	8 Nov. 1920
Prof. John Cameron, M. D., D. Sc., F. R. SS. E. & C.	8 Nov. 1920	"	20 Nov. 1922
Prof. Carleton Bell Nickerson, M. A.	20 Nov. 1922	"	12 Nov. 1924
Stephen Galway Ritchie, B. A., D. M. D.	12 Nov. 1924	"	12 Oct. 1926
Prof. John Hamilton Lane Johnstone, M. Sc., Ph.D., M.B.E.	13 Oct. 1926	"	10 Oct. 1928
Prof. Douglas McIntosh, Ph.D., F.R.S.C.	10 Oct. 1928	"	

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its transactions from 4th January to 3rd. December, 1859) led up to the establishment of the Nova Scotian Institute of Natural Science in December, 1862.

Note.—The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st. December, 1862. On 4th March, 1890, the name of the Society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

Since 1879 the Presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

APPENDIX.

LIST OF MEMBERS DECEMBER, 1929.

	Date of Election		
Allan, W. S., St. John, N. B. (Died 25 Mar., 1929)	5	Dec.,	1927
Allen, John S., SS. "John MacKay," Halifax	1	Oct.,	1928
Babkin, Prof. Boris, M.D., D.Sc., McGill University, Montreal, P.Q	26	Feb.,	1925
Bateson, S., Dalhousie University, Halifax	4	Nov.,	1929
*Bayne, Prof. Parker M., M.A., Acadia University, Wolfville, N. S	28	Mar.,	1928
Beatty, S. A., B.A., Fisheries Experimental Station (Atlantic), Halifax	4	Nov.,	1929
Bell, Prof. Hugh Philip, Ph.D., Dalhousie University, Halifax	1	Dec.,	1920
Borrett, Major William Coates, Dartmouth, N. S	26	Feb.,	1925
*Bronson, Prof. Howard L., Ph.D., F.R.S.C., Dalhousie Univ., Halifax	9	Mar.,	1911
Burbidge, Dean George A., Dalhousie University, Halifax	7	Feb.,	1927
*Cameron, Prof. John, M.D., D.Sc., F.R.S.S. E.&C., Dalhousie Univ., Hfx	2	Nov.,	1915
*Chipman, H. Ritchie, Ph.D., Fisheries Experimental Station (Atlantic) Hfx	3	Oct.,	1921
Chisholm, H. M., Dalhousie University, Halifax	4	Nov.,	1929
*Colpitt, Parker R., Halifax	2	Feb.,	1903
Cooper, Douglas LeB. P., B.Sc., McGill University, Montreal, P.Q	9	Nov.,	1927
Copp, Prof. Walter Percy, B.Sc., Dalhousie University, Halifax	28	Apr.,	1921
Creighton, Prof. Henry Jermain Maude, D.Sc., F.C.S., Swarthmore, Penn	7	Jan.,	1908
Cruickshank, Prof. E.W.H., M.D., D.Sc., Ph.D., Dalhousie Univ., Halifax	4	Mar.,	1929
Cumming, Melville, LL. D., Halifax	5	Nov.,	1928
Cunningham, Allen Rupert, M. D., Halifax	1	Dec.,	1921
*Davis, Charles Henry, C. E., New York, N. Y	5	Dec.,	1900
Dentith, Francis Wm. Hubert, B. Sc., Montreal, P.Q	13	Mar.,	1922
Dimmitt, R. F., B. A., Dartmouth, N. S	5	Nov.,	1928
*Doane, Francis William Whitney, City Engineer, Halifax	3	Nov.,	1886
Duchemin, Warren J., B. A., Dalhousie University, Halifax	2	Dec.,	1929
Edwards, George Arnold, M.I.R.E., Halifax	7	Jan.,	1929
Ellis, Miss Marjorie F., B. Sc., Dalhousie University, Halifax	3	Jan.,	1928
Gibbs, Prof. Owen S., M.B., Ch.B., Dalhousie University, Halifax	26	Feb.,	1925
Gowanloch, Prof. James Nelson, B.Sc., Dalhousie University, Halifax	4	Dec.,	1923
Grant, Gordon A., M.A., Dalhousie University, Halifax	9	Nov.,	1927
Hall, John C., M.Sc., Harvard University, Cambridge, Mass	4	Feb.,	1929
Hamer, Prof. Richard, Ph.D., Acadia University, Wolfville, N. S	7	Jan.,	1929
Hardy, Prof. W. E., B. Sc., N. S. Technical College, Halifax	30	Nov.,	1922
*Henderson, Prof. George Hugh, Ph.D., F.R.S.C., King's College, Halifax	2	Nov.,	1915
Hess, Ernest, M.Sc., McGill University, Montreal, P.Q	9	Nov.,	1927
Houghton, Lt. Com. F.L., R.C.N., Halifax	7	Jan.,	1929
Huntsman, Prof. A. G., M.B., F.R.S.C., Univ. of Toronto, Toronto, Ont	7	Feb.,	1927
Jackson, Wilfred J., Ph. D., New Jersey State College, New Brunswick, N.J.	9	Nov.,	1927
Jefferson, W. E., B. Sc., Halifax	3	Dec.,	1928
Johnstone, Prof. John H. L., Ph.D., M.B.E., Dalhousie Univ., Halifax	2	Dec.,	1912
King, Prof. Harold S., Ph.D., Dalhousie University, Halifax	30	Nov.,	1922
King, Mrs. H. S., M. A., Armdale, Halifax	30	Nov.,	1922
Leim, A. H., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	9	Nov.,	1927
McInnes, Hector, LL.B., K.C., Halifax	27	Nov.,	1889
McIntosh, Prof. Donald Sutherland, M.Sc., Dalhousie Univ., Halifax	9	Mar.,	1911
McIntosh, Prof. Douglas, D.Sc., F.R.S.C., Dalhousie Univ., Halifax	4	Dec.,	1923
*McKay, Alexander Howard, B.A., B.Sc., LL.D., F.R.S.C., Hon. Colonel, Dartmouth, N. S. (Died 19 May, 1929) Assoc. Member, 11 Jan. 1875	11	Oct.,	1885
*MacKay, George M. Johnstone, M.A., M.Sc., Schenectady, N. Y	28	Dec.,	1903
*Mackenzie, President A. Stanley, Ph.D., F.R.S.C., Dalhousie Univ., Hfx	7	Nov.,	1905
Mackenzie, Donald J., M.D., Pathological Institute, Halifax	7	Feb.,	1927
McKnight, Prof. William Ferrier, B.Sc., N.S. Technical College, Halifax	4	May,	1923
Mader, Victor O., M.D., Halifax	7	Feb.,	1927
Marshall, Clyde, M.D., Halifax	4	Mar.,	1929
Marshall, Mrs. Frances B., Ph.D., Halifax	4	Mar.,	1929
Matheson, Donald J., B.Sc., Science Master, Hfx. County Academy, Hfx	2	Nov.,	1915
Mennie, J. H., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	4	Nov.,	1929
Mitchell, Capt. W. F., Halifax	5	Dec.,	1927
Morton, John McLeod, M.Sc., Princeton University, Princeton, N.J	30	Jan.,	1928
Musgrave, Forrest F., B.A., University of Toronto, Toronto, Ont	9	Nov.,	1927
*Nicholls, Albert, G., M.D., F.R.S.C., Montreal, P.Q	2	Nov.,	1915

Life Member.

	Date of Election.		
Nickerson, Prof. Carleton Bell, M.A., Dalhousie University, Halifax	9	Mar.,	1911
Nickerson, J. L., M.A., Princeton University, Princeton, N.J	7	Feb.,	1927
Piers, Harry, Curator Prov. Museum & Librarian Prov. Science Library, Hfx.	2	Nov.,	1888
*Ritchie, Stephen Galway, B.A., D.M.D., Halifax	3	Oct.,	1918
*Robb, Donald W., Amherst, N. S	4	Mar.,	1890
Robertson, William G., Halifax	27	Feb.,	1920
Sanborn, J.R., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	4	Nov.,	1929
Sandoz, Georges A., Halifax	26	Feb.,	1925
Schwartz, Hugh W., M.D., Halifax	3	Mar.,	1920
Sexton, Prof. Frederic H., D.Sc., Director of Technical Education, Halifax	18	Dec.,	1903
Smith, E.A., Ph.D., Secaucus, N. J	3	Dec.,	1925
*Smith, Prof. H. W., B.Sc., Truro, N. S. (Ord. Member, Dec. 1900)	6	Jan.,	1890
Smith, Prof. Ralph P., M.B., C. M. Dalhousie University, Halifax	9	Nov.,	1927
Startup, C. W., B.Sc., Dalhousie University, Halifax	2	Dec.,	1929
*Stewart, Lt. Col. John, M.B., C.M., Dalhousie Univ., Hfx.(Sen. Ord. Mem.)	12	Jan.,	1885
Todd, Ebenezer Walter, B A., Dalhousie University, Halifax	27	Nov.,	1919
Whyte, Earle Forrester, Ph.D., Halifax	1	Dec.,	1920
Wilson, Miss Anna M., M.Sc., Fisheries Experimental Station (Atlantic), Hfx	4	Feb.,	1929
*Winfield, James H., Halifax	2	Dec.,	1903
*Woodbury, William Weatherspoon, B.Sc., D.D.S., Halifax	30	Nov.,	1916
*Yorston, William G., C.E., Halifax	12	Nov.,	1892
Young, Prof. Elrid Gordon, Ph.D., Dalhousie University, Halifax	26	Feb.,	1925
Young, J. Clement, B.A., Dalhousie University, Halifax	2	Dec.,	1929

ASSOCIATE MEMBERS.

*Bigelow, Prof. Henry B., Ph.D., Harvard University, Cambridge, Mass	7	Jan.,	1929
Bigelow, Prof. H. E., Ph.D., Mt. Allison University, Sackville, N.B	3	Dec.,	1928
Chaisson, Arthur F., Ph.D., St. Francis Xavier Univ., Antigonish, N.S	9	Nov.,	1927
*Churchill, Frederick C., Hantsport, N.S	3	Apr.,	1919
*Connolly, Prof. C.J., Ph.D., St. Francis Xavier Univ., Antigonish, N.S	5	Nov.,	1911
Frame, G. F., B.A	5	Nov.,	1928
Fraser, Prof. Roy, B.S.A., M.A., Mt. Allison Univ., Sackville, N. B	7	Jan.,	1929
Haley, Prof. Francis Raymond, D.Sc., Acadia University, Wolfville, N.S	5	Nov.,	1901
Harlow, Prof. L.C., Ph.D., Agricultural College, Truro, N.S	23	Mar.,	1905
Hatcher, Prof. Albert G., M.A., R.C.N. (Retired), Memorial College, St. John's, Nfld	9	Dec.,	1914
*MacKay, Hector H., M.D., New Glasgow, N.S	4	Feb.,	1902
Munro, Prof. Lloyd A., Ph.D ., University of Manitoba, Winnipeg, Man	1	Nov.,	1922
Murray, Prof. Daniel Alexander, Ph.D., McGill University, Montreal, P.Q	18	Dec.,	1903
Roscoe, Prof. Muriel V., Ph.D., Acadia University, Wolfville, N.S	7	Jan.,	1929
Tufts, Robie Wilfred, Chief Migratory Bird Officer, Wolfville, N.S	3	Oct.,	1921

CORRESPONDING MEMBERS.

Ami, Henry M., D.Sc., F.G.S., F.R.S.C. Ottawa, Ont	2	Jan.,	1892
Barbour, Major J. H., R.A.M.C., F.L.S., London, Eng	28	Dec.,	1911
Bethune, Rev. Charles J. S., D. C. L., F. R. S. C., Toronto, Ont. (Senior Corresponding Member)	29	Dec. ,	1868
Cox, Prof. Philip, Ph.D., University of N. B., Fredericton, N. B	3	Dec.,	1902
Dobie, W. Henry, M.D., Chester, England	3	Dec.,	1897
Faribault, E. Rudolphe, D. Sc., F. R. S. C., Geol. Survey, Ottawa (Assoc. Member, Mar. 6, 1888)	3	Dec.,	1902
Ganong, Prof. William F., Ph.D., Northampton, Mass., U. S. A	6	Jan.,	1890
Gates, Reginald Ruggles, Ph. D., F. L. S., London, Eng	30	Nov.,	1916
Harris, David Fraser, M.D., D.Sc.), F.R. SS. E. & C., care of Authors' Club, London, England. (Ord. Member, 29 Feb., 1912)	2	Dec.,	1924
Matheson, Prof. Robert, Ph.D., Cornell University, Ithica, U. S. A	30	Nov.,	1916
Mowbray, Louis L., Director of Miami Aquarium, Miami, Fla	3	May.,	1907
Peter, Rev. Brother Junian	12	Dec.,	1889
Prichard, Prof. Arthur H. Cooper, Rome, Italy	4	Dec.,	1901
Prince, Edward E., LL.D., D.Sc., Ottawa	5	Jan.,	1897

*Life Member.

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863	“	8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	9 Oct. 1873	“	9 Oct. 1878
William Gossip	9 Oct. 1878	“	12 Oct. 1880
John Somers, M. D.	13 Oct. 1880	“	26 Oct. 1883
Robert Morrow	26 Oct. 1883	“	21 Oct. 1885
John Somers, M. D.	21 Oct. 1885	“	10 Oct. 1888
Prof. James Gordon MacGregor, M.A., D.Sc., F.R.S., F.R.S.C.	10 Oct. 1888	“	9 Nov. 1891
Martin Murphy, C. E., D. Sc., I. S. O.	9 Nov. 1891	“	8 Nov. 1893
Prof. George Lawson, Ph. D., LL.D., F.I.C., F. R.S. C.	8 Nov. 1893	“	10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. Sc., F.G.S., F.R.S.C., I. S. O.	18 Nov. 1895	“	8 Nov. 1899
Alexander McKay, M. A.	8 Nov. 1897	“	20 Nov. 1899
Alexander Howard MacKay, B.A., B.Sc., LL.D., F.R.S.C.	20 Nov. 1899	“	24 Nov. 1902
Henry Skeffington Poole, M.A., D.Sc., A.R.S.M., F.G.S., F. R. S. C.	24 Nov. 1902	“	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905	“	11 Nov. 1907
Prof. Ebenezer Mackay, Ph. D.	11 Nov. 1907	“	12 Dec. 1910
Watson Lenley Bishop	12 Dec. 1910	“	11 Nov. 1912
Donald MacEachern Fergusson, F. C. S.	11 Nov. 1912	“	12 Oct. 1915
Prof. David Fraser Harris, M. B., C. M., M. D., B. Sc., D. Sc., (London) F. R. SS. E. & C.	13 Oct. 1915	“	18 Nov. 1918
Prof. Howard Logan Bronson, Ph. D., F. R. S. C.	18 Nov. 1918	“	8 Nov. 1920
Prof. John Cameron, M. D., D. Sc., F. R. SS. E. & C.	8 Nov. 1920	“	20 Nov. 1922
Prof. Carleton Bell Nickerson, M. A.	20 Nov. 1922	“	12 Nov. 1924
Stephen Galway Ritchie, B. A., D. M. D.	12 Nov. 1924	“	12 Oct. 1926
Prof. John Hamilton Lane Johnstone, M. Sc., Ph.D., M.B.E.	13 Oct. 1926	“	10 Oct. 1928
Prof. Douglas McIntosh, Ph.D., F.R.S.C.	10 Oct. 1928	“	

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its transactions from 4th January to 3rd December, 1859) led up to the establishment of the Nova Scotian Institute of Natural Science in December, 1862.

Note.—The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 4th March, 1890, the name of the Society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

Since 1879 the Presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

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THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

VOLUME XVII

PART 1

SESSION 1926-1927

HALIFAX
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PROCEEDINGS

OF THE

Nova Scotian Institute of Science

SESSION OF 1926-1927

(Vol. xvii, Part 1)

65TH ANNUAL SESSION.

ANNUAL BUSINESS MEETING.

Dental Lecture Room, Dalhousie College,
Halifax, 13th October, 1926.

THE PRESIDENT, DR. STEPHEN G. RITCHIE, in the chair.

Other members present: DR. J. H. L. JOHNSTONE, D. J. MATHESON, PROF. D. S. MCINTOSH, DR. A. H. MACKAY, DR. D. MCINTOSH, DR. G. H. HENDERSON, DR. E. G. YOUNG, PROF. J. W. GOWANLOCH, E. TODD, DR. B. BABKIN, REV. BRO. W. B. CORNELIA, PROF. W. P. COPP, and H. PIERS.

The meeting was opened by the PRESIDENT's address printed in full on page viii following.

The Treasurer's report was then presented by D. J. Matheson, showing that the receipts for the year were $1946.40, the expenditures, $68.98; balance in hand, $1877.44 and balance in reserve fund, $170.87; while the permanent endowment fund is $1,500. The Treasurer pointed out that there would be chargeable against the balance the cost of printing the Transactions, Vol. 16, parts 1-4, now in press.—The report was received and adopted.

The Librarian's report was presented by H. Piers, showing that 1,505 books and pamphlets had been received through the exchange-list during the year 1925, and 875 have been received during the nine months, Jan. to Sept. 1926. The total number of books and pamphlets received by the entire Provincial Science Library (with which that of the Institute is incorporated) during 1925, was 1,652. The total number in the Science Library on 31st. Dec., 1925, was 71,886. Of these, 53,834 (about 75 per cent.) belong to the Institute, and 18,052 to the Science Library proper. 145 books were borrowed in 1925, besides those consulted in the library.

No binding or purchasing of books has been done, there having been no money grant at the Library's disposal since 1907.—The report was received and adopted.

Dr. MacKay reported progress in printing the Transactions, vol.16. Part 1 has been printed and part 2 is nearly completed.

Officers for the ensuing year (1926-27) were elected as follows:

President,—PROF. JOHN HAMILTON LANE JOHNSTONE, PH. D., M. B. E., *ex officio* F. R. M. S.
First Vice-President,—ALBERT G. NICHOLLS, M. D., D. Sc.
Second Vice-President,—PROF. DOUGLAS McINTOSH, PH.D.
Treasurer,—DONALD J. MATHESON, B. Sc.
Corresponding Secretary,—PROF. D. S. McINTOSH, M. Sc.
Recording Secretary and Librarian,—HARRY PIERS.
Councillors without office,—ALEXANDER H. MACKAY, LL. D. F. R. S. C.; PROF. HAROLD S. KING; PROF. GEORGE H. HENDERSON, PH. D.; PROF. E. GORDON YOUNG, PH. D.; PROF. JAMES N. GOWANLOCH, B. A., Sc.; REV. BROTHER WILLIAM B. CORNELIA; STEPHEN G. RITCHIE, D. M. D.
Auditors,—PARKER R. COLPITT and PROF. W. P. COPP.

DR. JOHNSTONE thanked the society for the honor done him in electing him President.

On motion of Mr. Piers and Dr. MacKay a vote of thanks was presented to the retiring President, Dr. Ritchie.

On motion of Dr. D. McIntosh and Dr. Bronson a vote of thanks was presented to the Recording Secretary who has served in that office for thirty-two years.

First Ordinary Meeting.

Dalhousie Medical Science Building, College Street, Halifax, 15*th November,* 1926.

The President, Dr. Johnstone, in the chair.

Dr. Young, as chairman of the Scientific Exhibition Committee, reported that it had arranged for such an exhibition to be held under the Institute's auspices on the 26th and 27th inst.

The following papers were read:

(1) Some Seasonal Changes in Tide-pool Flora.—by Prof. Hugh P. Bell. (See Transactions, page 1).

(2) The Effect of Environmental Factors on the Development and Growth of *Littorina.*—By F. Ronald Hayes. (See Transactions, page 6). The subject was discussed by Prof. Nickerson, Dr. Young, Prof. Bell, Dr. Henderson, and Mr. Piers.

(3) An Installation for the Preparation of Radium Emanation for Therapeutic Use.—By Prof. G. H. Henderson, Ph. D. (See Transactions, page 14). Remarks on the subject were made by Prof. D. S. McIntosh.

Scientific Exhibition.

Medical Science Building, Halifax, 26*th* and 27*th November,* 1926.

A free public Scientific Exhibition was held by the Institute in nine rooms of the Medical Science Building, College Street, from 6 to 10 p. m. of Friday, 26th November, and from 2.30 to 4.30 and from 8 to 10 p. m. of Saturday, 27th November.

The Committee directly in charge consisted of Dr. Young, chairman, Dr. Ritchie, Dr. Henderson, Dr. Bell, Prof. King, Prof. Gowanloch, and the President, Dr. Johnstone. The Institute was assisted by the various departments of Dalhousie and King's Universities, the Maritime College of Pharmacy, the Nova Scotia Technical College, the Atlantic Experimental Station for Fisheries, and C H N S Radio Broadcasting Station, as well as by students who aided in installing the exhibits and explaining them to visitors.

The exhibits and demonstrations related to physics, electricity, radio, chemistry, biochemistry, geology, botany, bacteriology, zoology, the fisheries, physiology, pathology, histology, embryology, pharmacy, and dentistry; and a brief printed guide, in folder form, was sold for ten cents.

The exhibition proved to be very popular, being visited by people of all classes, and was successful beyond the expectations of its promoters. On the first evening it was estimated that at least 1,500 persons attended; at the special session on Saturday afternoon, about 500; and in the evening of that day, at least 2,500; making a total attendance of about 4,500. The local press spoke of it in the highest terms.

It was probably the first really notable exhibition of its kind ever held in the province.

Second Ordinary Meeting.

Medical Srience Building, Halifax, 13th December, 1926.

The President, Dr. Johnstone, in the chair.

Prof. O. S. Gibbs, M. B., Ch. B., gave a demonstration of "The Measurement of Renal Secretion." (See Transactions, page 21). The subject was discussed by Drs. Young and Babkin.

Prof. Boris Babkin, D. Sc., presented a paper on "Digestion in *Fundulus heteroclitus*" (see Transactions, page 20), which was discussed by Dr. Young, Mr. Piers, and Dr. Dreyer.

K. H. Butler, M. A., and Prof. D. McIntosh, D. Sc., presented a paper on "Compounds of the Halogens with each other, and with the Halogen Hydrides." (See Transactions, page 23). It was discussed by Drs. Young and Henderson.

Dr. Young read a report from the Committee in charge of the recent Scientific Exhibition.

On motion of Mr. Piers it was resolved that the thanks of the Institute be presented to the various departments of Dalhousie and King's Universities, the Maritime College of Pharmacy, the N. S. Technical College, the Atlantic Experimental Station for Fisheries, and CHNS Broadcasting Station, as well as the N. S. Tramways and Power Co. for their valuable assistance in making a success of the exhibition, and to those students who aided in installing the exhibits and explaining them to visitors.

Third Ordinary Meeting.

Medical Science Building, Halifax, 10th January, 1927.

The President, Dr. Johnstone, in the chair.

A paper by Prof. N. B. Dreyer, M. R. C. S., on "The Excretion of Acetone Bodies on Diets of Fat and Carbohydrate" (see Transactions, page 26), and one by Pror. J. N. Gowanloch, B. Sc., on "The Tintinnoina of Eastern Canada", were read by title.

Stephen G. Ritchie, D. M. D., read a paper entitled, "A Critical Study of Certain of the Simpler Wave Forms," illustrated by diagrams. The subject was discussed by Mr. Piers.

Fourth. Ordinary Meeting.

Medical Science Building, Halifax, 14th February, 1927.

The President, Dr. Johnstone, in the chair.

It was reported that the following had been elected ordinary members on the 7th inst.: Dr. A. G. Huntsman, Dr. D. J. Mackenzie, Dr. Victor O. Mader, J. L. Nickerson, B. A., and George A. Burbidge, all of Halifax.

Prof. Harold S. King, presented a paper on "Attemps to Separate the Isotopes of Mercury by Chemical Means". (See Transactions, page 28). The subject was discussed by Drs. Young, McIntosh, Henderson and Johnstone.

Prof. O. S. Gibbs, M. B., Ch. B., presented a paper on "A Method of Measuring Renal Blood Flow". (See Transactions, page 27). It was discussed by Drs. Young, Babkin and Henderson.

Prof. E. G. Young, Ph. D., presented a paper on "The Technique of Fractional Fermentation." (See Transactions, page 61). It was discussed by Dr. Babkin, Prof. King, Mr. Todd, and Drs. Henderson, McIntosh, and Gibbs.

Fifth Ordinary Meeting.

Medical Science Building, Halifax, 21st. March, 1927.

The President, Dr. Johnstone, in the chair.

The following papers were presented:

(1) A Simple Automatic Mercury Still.—By Prof. H. L. Bronson, Ph. D. (See Transactions, page 80).

(2) Chemical Manipulation: Physico-Chemical Apperatus.—By Prof. Douglas McIntosh, Ph. D. (See Transactions page 71).

(3) The Problem of the Pancreatic Bladder.—By Prof. R. J. Bean, M. S., and Prof. N. B. Dreyer, M. R. C. S. (See Transactions, page 63). This paper was discussed by Mr. Todd and Drs. Babkin and Huntsman.

The President announced that the Nova Scotian Government had restored the grant of five hundred dollars to the Provincial Science Library, which had been without such financial aid since 1907.

SIXTH ORDINARY MEETING.

Medical Science Building, Halifax, 11th April, 1927.

THE PRESIDENT, DR. JOHNSTONE, in the chair.

The following papers were presented:

(1) The Autolytic Power of *Bacillus coli communis.*—By PROF. E. GORDON YOUNG, PH. D. (See Transactions, page 79). The paper was discussed by the PRESIDENT and DRS. BABKIN, HUNTSMAN and MCINTOSH.

(2) The Vascular Reaction of the Submaxillary Gland to Histamine.—By MISS MARGARET E. MACKAY, M. A. (See Transactions, page 107). The paper was discussed by DRS. YOUNG, BABKIN and BEAN.

(3) Studies on Pancreatic Secretion. — By H. S. MORTON, B. A. (See Transactions, page 91). Discussed by DRS. BABKIN, YOUNG, MCINTOSH and HUNTSMAN.

SEVENTH ORDINARY MEETING.

Medical Science Building, Halifax, 6th May, 1927.

THE PRESIDENT, DR. JOHNSTONE, in the chair.

A paper was presented by DOUGLAS DEB. COOPER on "The Specific and Latent Heats of Acetaldehyde and Paraldehyde." (See Transactions, page 82). The subject was discussed by the PRESIDENT and DRS. BRONSON, MCINTOSH and HUNTSMAN.

G. C. LAURENCE, B. Sc., presented a paper on "A New Determination of the Range of Alpha Particles from Uranium I and Uranium II. (See Transactions, page 103). It was discussed by DRS. MCINTOSH, BRONSON and HENDERSON, and MR. TODD.

HARRY PIERS,
Recording Secretary.

Presidential Address, 1925-6.

By Stephen G. Ritchie, B. A., D. M. D.

(13 October 1926)

Gentlemen:—

It is my pleasure to present herein a report of the proceedings of the 64th Annual Session of the Institute.

During the session your Council held eight meetings. The ordinary monthly sessions numbered seven. At these it was noticed that the attendance had steadily improved.

By vote of the Council, five new members were admitted. I regret to report one death during the year, that of Dr. Martin Murphy who died at St. Catherines, Ontario, January 9th, 1926, aged ninety-six. Dr. Murphy, one of the most noted engineers ever identified with this Province, was not at the time of his death a member of the Institute; but he was its ninth President from November 1891 to 1893.

The activity of the Council members during the year has resulted in a wonderful improvement in a number of scientific papers presented during the session. In the course of seven meetings nineteen papers were read, several of which are important contributions to scientific literature and research. In glancing over the titles it was noted that six are chemical, four physical, three biological, four medical, one mathematical and one geological.

Such results are indeed encouraging, and there is no reason to think that like results may not be obtained in the session now initiated. All that is necessary is activity on the part of the members of the Council similar to that displayed in the year just closed.

It would take too much time to discuss scientific achievements in general during the year, but I should like to call your attention to the remarkable advances made towards the attainment of television. The transmission and almost instantanious reproduction of individual pictures or photographs is already a commonplace, and it may be safely predicted that television is just around the corner.

There were no popular lectures delivered during the session. It was proposed instead to hold an exhibition or demonstration of scientific progress which would be of interest to the public. Owing to circumstances over which your Council had no control this matter was held over; but it is hoped that it will take place during the coming session, sometime before the Christmas season. The committee in charge was continued with that end in view.

The provincial grant of five hundred dollars to the Institute of Science was again included in the estimates, so that it was unnecessary to interview the Government in that regard. The Council, however, was unanimous in thinking that steps should be taken to have the grant to the Provincial Science Library restored. This grant of five hundred dollars, for the purposes of supplying up-to-date text books, manuals, etc., was deleted from the estimates some years ago for reasons unknown. It was therefore thought advisable to appoint a committee consisting of Dr. A. S. McKenzie, Dr. A. G. Nichols, Dr. Douglas, McIntosh, Dr. J. H. L. Johnstone and your President to interview the Minister of Natural Resources, the Hon. J. A. Walker, to see what could be done. Mr. Walker met your committee in a very friendly and sympathetic manner and promised his assistance on the receipt of a formal letter from the committee, setting forth the facts of the case. This letter was duly forwarded. It will be advisable to follow the matter up before the estimates come down in the nest session of the Provincial Legislature.

I take this opportunity of extending my sincere thanks to the members of the Council for the enthusiasm displayed, the uniform courtesy, support and assistance extended to me throughout the past session in carrying on the program of the Institute. I should also like to express again to the members my appreciation of the honor they conferred on me in electing me to the presidency for the second time. I have prized the honor very highly and I trust that my efforts on behalf of the Institute have met with your approval.

JAN 21 1929

PROCEEDINGS

OF THE

Nova Scotian Institute of Science

SESSION OF 1927-28
(Vol. xvii, Part 2)

66th Annual Business Meeting.

Dalhousie Medical Science Building, Halifax,
12*th October*, 1927.

The President, Dr. J. H. L. Johnstone, in the chair.

Other members present: Dr. D. McIntosh, D. J. Matheson, Prof. D. S. McIntosh, Dr. A. H. MacKay, Prof. H. S. King, Dr. E. G. Young, Prof. J. N. Gowanloch, Rev. Bro. Cornelia, Dr. H. L. Bronson, Dr. J. Cameron, G. Sandoz, Prof. G. E. Burbidge, and H. Piers.

The President delivered the opening address as follows:—

Gentlemen:—

It is a privilege of your president to briefly review the events of the sixty-fifth annual session of the Institute.

I am glad that one of the duties which is laid down by our regulations, viz. to give a brief sketch of the life and scientific work of members who have died during the year, does not have to be performed.

In accordance with custom we will receive reports on our library and finances. It is my duty to review the happenings of the session. The year 1926-27 is a noteworthy one in our history for two reasons—First, a science exhibition open to the public, was held by the Institute in cooperation with the science departments of Dalhousie University; Second, the government grant of $500 was restored to the provincial science library after a lapse of twenty years.

The primary object in offering the exhibition was to stimulate a more widespread interest in pure science and it's possibilities. To awaken in even a few an appreciation of the value of science is to make them better citizens and so make our Province a better place to live in. From the many expressions of opinion from individuals and the press, from the fact that the attendance was nearly 5,000, there is little doubt that the exhibition was one of the most successful educational features of recent years. The committee in charge received enthusiastic support and cooperation from the Science teaching staffs and students of Dalhousie University, the faculty and students of the Maritime College of Pharmacy, the electrical department of the Nova Scotia Technical College, the Atlantic Experiment Fisheries Station and radio-station CHNS. I take this opportunity, on behalf of the Institute, of thanking them for their generous assistance.

During the past year 19 contributions were presented, of which 10 might be classed as biological, 5 chemical and 4 in physics. The average length of paper was 5.6 pages. A comparison with previous years is of interest. The number of papers presented this year has never been exceeded and only on one occasion equalled, viz. in 1925-26.

Years	*Average no. of Papers*
1890—1906	10
1906—1916	8.8
1916—1919	4

The council feels that there is no reason why the present high mark should not be kept up, provided a concerted effort is made to secure and publish the results of all scientific work done by investigators in this province, even if only as an abstract. From the increased number of papers presented in the past two years we must not too hastily infer that real progress has been made, nevertheless it is an encouraging sign. It is gratifying to note that 7 papers were presented by student members, and in one case the paper received the high praise of Sir E. Rutherford, and it was chiefly responsible for the author's appointment to an 1851 Exhibition Science Research Scholarship.

You will hear from Mr. Piers the annual report of the Science Library. May I point out that altho the library is controlled by the government, it was founded by the Institute of Science and a large part of it belongs to us, being merely held in trust by the government. For these reasons the Institute is naturally interested in the success of the library, and we all should feel grateful at the restoration of the annual grant from the government. The library has grown rapidly, chiefly in pamphlets and periodicals received from all parts of the world, in exchange for our Transactions. In the past, because of lack of funds, it was impossible to have any binding done, consequently many of these pamphlets have been not readily accessible. The librarian has allotted a generous amount for binding purposes and during the past summer a number of the more valuable periodicals were bound. A small library committee has been appointed by your council to consult with Mr. Piers.

Owing to unforseen delays caused by the printer, the Transactions of the year 1920-1926 are still in press, but it is expected that they will be ready for mailing in a short time. As a result of the initiative and energy of our editor Dr. A. H. MacKay and a welcome change in printer, The Proceedings and Transactions for 1926-27 are now completed and ready for distribution.

Our membership, 70 ordinary and 12 associate, compares very favorably with past years, e. g. in 1890 the ordinary and associates numbered 76. Five new ordinary members were proposed and elected during the year. It should be our aim to have on the membership list the name of every man in the province who has the ability to make contributions to science and all the others who are willing to encourage others by their interest and annual fees. With the cöoperation of each member it should be possible to increase the ordinary membership to at least 300. I would suggest that the incoming council concern itself with this important matter.

May I take this opportunity of expressing to the members my appreciation of the honor in electing me to the presidency of the Institute and of thanking the council for its cooperation thruout the past year.

The Treasurer's report was presented by D. J. Matheson, showing that the receipts for the year were $2,547.77; the expenditures, $471.06; balance in hand (in current account), $2,076.71; and the balance at credit of reserve fund, $175.97; while the permanent endowment fund is $1,500.00.—The report was received and adopted.

The Librarian's report was presented by Mr. Piers, showing that 1,170 books and pamphlets had been received through the exchange-list in 1926; and 1,005 during the nine months, Jan. to Sept., 1927. The total number of books and pamphlets received by the entire Provincial Science Library (with which that of the Institute is incorporated) during 1926, was 1,424. The total number in the Science Library on 31st. Dec. 1926, was 73,310. Of these, 55,004 (about 75 per cent.) belong to the Institute, and 18,306 to the Science Library proper. 92 books were borrowed in 1926, besides those consulted in the library. The Library had been without a grant for the purchase of books since 1907. Owing, however, to the representations of the Institute, the sum of $500 was placed to its credit in the governmental estimates for this year. With this some volumes of the Proceedings of the Royal Society of England have been bound, and the remainder of the money has been expended on the purchase of much needed books on pure and applied science. The purchasing power of this grant has been greatly lessened from what it was in former years, owing to the increased cost of publishing.—The report was received and adopted.

Officers for the ensuing year, 1927-28, were elected as follows:

President,—Prof. John Hamilton Lane Johnstone, Ph.D., M.B.E., *ex officio* F.R.M.S.
First Vice-President,—Prof. Douglas McIntosh, Ph.D., F. R. S. C.
Second Vice-President,—Prof. E. Gordon Young, Ph.D.
Treasurer,—Donald J. Matheson, B.Sc.

Corresponding Secretary,—PROF. DONALD SUTHERLAND McINTOSH, M.Sc.
Recording Secretary and Librarian,—HARRY PIERS.
Councillors without office,—A. H. MACKAY, LL.D., F.R.S.C., PROF. J. N. GOWANLOCH, REV. BRO. W. B. CORNELIA, S. G. RITCHIE, D.M.D., A. G. HUNTSMAN, B. A., M. B., F. R. S. C., and PROF. G. A. BURBIDGE.
Auditors,—P. R. COLPITT and PROF. W. P. COPP.

FIRST ORDINARY MEETING.

Medical Science Building, Halifax,
21*st. November*, 1927.

THE PRESIDENT, DR. JOHNSTONE, in the chair. Attendance, 24.

It was reported that the following had been elected members on 9th Nov.: PROF. JOHN GEOFFREY ADSHEAD, B.A., King's College; DOUGLAS DEB. P. COOPER, B.Sc.; WILFRED J. JACKSON, PH.D., Dalhousie University; GEORGE O. LANGSTROTH, B.A., Dalhousie University; WILLIAM G. MORAN, B.Sc., Dalhousie University; FORREST F. MUSGRAVE; PROF. RALPH SMITH, M.D., Dalhousie University; DR. A. H. LEIM, Atlantic Experimental Station for Fishes; ERNEST HESS, M.A., Atlantic Experimental Station for Fisheries, all of Halifax; C. CAISSON, Dept. of Education; Harvard University, Cambridge, Mass., U. S. A.; and GORDON A. GRANT, B.Sc., Halifax.

The following papers were presented:

(1) An Electric Perfusion Pump with special reference to its use in Blood-flow.—By PROF. O. S. GIBBS, M.B., CH.B. (See Trans., p 1.)

(2) Addition Compound of Hydrogen Chloride with Ether and Acetone.—By PROF. DOUGLAS McINTOSH, PH.D., F. R. S. C. (See Trans., p 4).

SECOND ORDINARY MEETING.

Medical Science Building, Halifax,
12*th December*, 1927.

THE PRESIDENT, DR. JOHNSTONE, in the chair. Attendance, 13.

It was announced that W. S. Allan, St. John, N. B., and C. R. K. Allen, Halifax, had been elected members on 5th Dec.

Mr. Piers presented a list of the books which had been purchased for the Provincial Science Library during the year, with the money voted by the Nova Scotian Government. He also described the principle followed in selecting new books, so that the additions might cover, as far as possible, the subjects within the scope of the library.

Prof. O. S. Gibbs, M.B., Ch.B., presented a paper "On the Distribution of Quinine in Blood." (See Trans., page 6).

Prof. Hugh P. Bell, Ph.D., presented a paper entitled, "A Comparative Study of the Algal Distribution of the Maritime Coast Line."

It was resolved that the Council appoint a committee to have charge of a science exhibition in 1928, if it sees fit.

Third Ordinary Meeting.

Medical Science Building, Halifax,
9th January, 1928.

The President, Dr. Johnstone, in the chair. Attendance, 21.

It was reported that George Eadie, M.B., Ph.D., and Miss Marjorie F. Ellis, of Halifax, had been elected members on the 3rd. inst.

It was announced that at the last Council meeting it had been decided that no popular lectures would be held this session, but that a science exhibition would be arranged for during the present year.

E. W. Todd, B.A., presented a paper on "The Removal of Sulphur from Illuminating Gas by Activated Carbon." (See Trans., p. 12).

Prof. Douglas McIntosh, Ph.D., presented a paper entitled "Notes on Isomorphism in Oxonium Compounds". (See Trans., p 8).

FOURTH ORDINARY MEETING.

Physics Lecture Room, Science Building, Studley, Halifax, 6th February, 1928.

THE PRESIDENT, DR. JOHNSTONE, in the chair. Attendance, 26.

It was announced that JOHN McLEOD MORTON, Halifax, had been elected a member on 30th Jan.

MISS MARJORIE F. ELLIS, B.Sc., read a paper entitled, "A Case of Vermiform Appendix in the Domestic Cat." (See Trans., p. 26).

PROF. JOHN CAMERON, M.D., D.Sc., F.R.S.E., presented a paper entitled, "Recent Researches on the Skull."

DR. MACKAY laid on the table the Proceedings and Transactions, vol. 16, parts 1-4, for sessions 1922-3 to 1925-6, which had just been received from the printer.

On motion a vote of thanks was presented to DR. MACKAY for his services as editor.

PROF. W. J. JACKSON, PH.D., gave a Demonstration of the Photo-electric Cell.

FIFTH ORDINARY MEETING

Medical Science Building, Halifax,
19*th March*, 1928.

THE PRESIDENT, DR. JOHNSTONE, in the chair. Attendance, 26.

PROF. O. S. GIBBS, M.B., CH.B., presented a paper on "A New Method of Measuring Blood-flow". (See Trans., p. 10).

D. LEB. COOPER, B.A., presented a paper, "Notes on the Action of Oxygen on Acetaldehyde." (See Trans., p. 32.)

PROF. D. S. MCINTOSH, M.Sc., presented a paper, "Notes on Glaciation in Cape Breton Island."

Abstract.—The opinion is advanced that the Northern Tableland, the Mabou highlands, and probably some other less high, flat areas of Northern Cape Breton were not covered by the Great Ice Sheet. Evidence in support of this opinion is set forth; and some reasons are stated, also, why it is thought that, at some time, a small ice-cap covered a part of the northern highlands.

GEORGES SANDOZ exhibited, described, and gave a demonstration of, a New Type of Loud-Speaker which he has devised and which is an improvement on those generally in use.

SIXTH ORDINARY MEETING.

Physics Lecture Room, Science Building, Studley, Halifax,
9th April, 1928.

THE PRESIDENT, DR. JOHNSTONE, in the chair. Attendance, 25.

It was announced that PROF. PARKER M. BAYNE, Acadia University, Wolfville, N. S., had been elected an associate member on 28th March.

THE PRESIDENT, DR. JOHNSTONE, gave a demonstration of the latest model of the Hilger (constant direction) Type of Spectroscope.

G. O. LANGFORTH, B. S., and D. LeB. COOPER, B.A., presented a paper on "The Specific Heat of Molybdenum, using an Adiabatic Calorimeter." (See Trans., p. 32).

S. S. SINGER, M.Sc., presented a paper entitled, "Preliminary Notes on the Mitochondria of the Parathyroid of the White Rat." (See Trans., p. 14).

SEVENTH ORDINARY MEETING.

Medical Science Building, Halifax.
21st May, 1928.

THE VICE-PRESIDENT, DR. D. McINTOSH, in the chair. Attendance, 14.

MISS ANNA M. WILSON, B.A., presented a paper on "Molecular Weight Determinations and Conduction in Liquified Sulphur Dioxide."

Abstract.—This paper gave an account of some experiments on liquified sulphur dioxide as a solvent. This material dissolves many compounds and gives some solutions which conduct the electric current. A number of non-polar substances such as chloroform, carbon tetrachloride and toluene were used to determine the boiling-point constant in a modified Beckman apparatus. It was found to be about 1.2 for 1000 grams of the solvent. Potassium iodide, sodium iodide and potassium sulphocyanate gave conducting solutions and anomalous results for their molecular weights. Compounds of the first two salts made at low temperatures showed a ratio of 13 and 2 molecules of the dioxide to one of the iodide.

Stephen G. Ritchie, B.A., D.M.D., delivered an address on "Bakelite, its Manufacture and Uses, particularly in Dental Work."

A paper by Miss Mabel A. Borden, B.A., on a Distribution and Limiting Factors of *Acmaea testudinalis*," was read by title.

Prof. Douglas McIntosh, D.Sc., presented a paper on "Experiments with Carefully Dried Substances." (See Trans., p. 34).

A vote of thanks was presented to the non-members, the Misses Wilson and Borden, for their contributions.

Harry Piers,
Recording Secretary.

PROCEEDINGS

OF THE

Nova Scotian Institute of Science

SESSION OF 1928-29
(Vol. XVII, Part 3)

67TH ANNUAL BUSINESS MEETING.

Dalhousie Medical Science Building, Halifax.
10*th October*, 1928.

The PRESIDENT, DR. J. H. L. JOHNSTONE, in the chair.

Other members present: DR. D. MCINTOSH, DR. E. G. YOUNG, D. J. MATHESON, PROF. D. S. MCINTOSH, DR. A. H. MACKAY, DR. H. S. KING, DR. S. G. RITCHIE, DR. G. H. HENDERSON, PROF. R. J. BEAN, PROF. C. B. NICKERSON, DR. H. L. BRONSON, CAPT. W. F. MITCHELL, DR. J. CAMERON, DR. O. S. GIBBS, DR. H. R. CHIPMAN, and H. PIERS.

The PRESIDENT delivered the opening address as follows:

Gentlemen:—

We meet tonight for two purposes, first to close the 66th session, second to begin another year in the history of the Institute. It is part of my duty as president to review briefly the events of the past year and make suggestions for the future.

Our membership has been increased by the addition of 18 ordinary and corresponding members, and it now numbers 100. It is a pleasure to record that in this as in last year we have suffered no loss by death. The recording secretary informs me that the average death loss is two per year, so either we are living longer or the average age of the members is less than formerly. It is with great regret that I record the resignation of the Rev. Brother Cornelia, formerly science master at St.

Mary's College. As a member of the Institute and for the past two years of its Council, Brother Cornelia has always shown a great interest in our welfare. I feel certain that he carries with him the best wishes of the members of this society.

During the session eight council and seven ordinary meetings were held. Eighteen papers were presented which may be classified as follows:

Physico-Chemical	8
Biological	4
Physiological	5
Geological	1

In addition to these original contributions, several demonstrations of apparatus were held and, judging from the reception given them by our members, it would appear desirable to continue and perhaps expand this phase of our activity.

It is a pleasure to note that there has been a marked increase, not only in the average attendance at the ordinary meetings, but also in the interest shown by the members in our activities.

At the 1928 meeting of the Royal Society at Winnipeg, this society was represented by Dr. A. G. Huntsman, who presented a report on our operations for the year.

At the beginning of our last session a committee was appointed by your Council to revise the publication exchange list. The history of this list is briefly as follows: At the first session of the Institute in 1862, Dr. Carteret Hill in his presidential address said—"to afford a well constructed and organized channel for the contributions to the general stock of knowledge for those among ourselves, who are interested in natural science, the Nova Scotian Institute has been established. We look forward to the time when our transactions shall be exchanged with the older and more important institutions and any new and well authenticated fact, having passed the ordeal of our local organization, shall be transmitted to the great centres of science and become the property of the whole world." This prophecy was realized in Hill's lifetime chiefly through the efforts of the late Dr. MacGregor and Mr. Bowman. There is published in the Transactions for 1894 a list showing the institutions to which the Transactions were sent. It is noted that the mailing list then included 709 names, scattered over the world and that 383 exchanges were received. It was found that the mailing list for 1927 numbered 700 and that exchanges were received from 244 institutions.

It was evident that this list, thirty-three years old, needed revision. After much labor your committee made up a new list totalling 526 names, which were placed on a card index system which is easily accessible. A circular letter asking for exchange was sent to 324 institutions. This energetic committee deserves the thanks of the Institute for the able manner in which it carried its program to completion.

You will no doubt have a report from the editor of the Proceedings. Few of us realize the great amount of time and effort which is given to this work by Dr. A. H. MacKay. His labors would be lessened and publication would be accelerated if those presenting papers would promptly send them to the editor. This year's volume would now be ready for distribution if it were not for the laxity of a few of the contributors.

We have received our usual yearly grant from the Provincial Government and the Science Library grant continues to be paid. The Science Library was commenced by this Institute in 1864 and entrusted to the care of the government in 1900 on condition that it should be made a public library and maintained by the Province in connection with the Provincial Museum. No grant was made nor was any interest taken in the library by the Provincial Government for many years. Due to the efforts of some of your members, and the late Mr. G. S. Campbell, the government grant was resumed in 1927, and the librarian, Mr. Piers, now has funds to do a limited amount of binding and to purchase a small number of books. The library at present constitutes a valuable nucleus around which to build a sound structure, which can be made of great value to the people of this Province. I respectfully request the members of this Institute to take an interest in its welfare and to utilize it as much as possible. I wish to suggest that each year the librarian have published in the daily press a list of the new books added, so that the public will come to realize the existence of this library and the books that are available.

In regard to our finances, I should like to call your attention to the fact that for the past ten years the cost of publishing our Proceedings has been continually increasing while our receipts have remained stationary. It is very evident that within the next few years we shall have either to increase our revenue or to decrease the size of our publication. To adopt the latter alternative means to decrease the number of papers published, which would be a backward step. The first alternative seems to offer the only satisfactory solution. Our income can be increased by additional Provincial Government grant *or* increase of annual fee paid by members *or* a large increase in membership; but best by a combination of the three methods. Apart from financial considerations, increase in membership is of vital importance to the welfare of this society. For the past number of years the new members elected have just been sufficient to balance the loss due to removal, resignation, etc. During the next year a determined effort should be made by each one of us to submit to the Council names of suitable candidates for membership.

In accordance with your wishes I appointed a committee under the chairmanship of Dr. D. McIntosh to arrange a science exhibition. This committee has arrangements well under way and you will tonight receive a progress report from its chairman.

May I take this opportunity of thanking the members of the Council, the recording and corresponding secretaries and the vice-presidents for the excellent services they have rendered the Institute during the past year. All have co-operated to the best of their ability, and that is saying much.

Again I wish to express to the members my thanks for the honor they have done me in electing me to the office of president.

The Treasurer's report was presented by D. J. Matheson, showing that the receipts for the year were $2,824.86; the expenditures, $1,296.31; balance in hand (in current account), $1,528.55; and the balance at credit of reserve fund, $181.22; while the permanent endowment fund is $1,500.00. The report was received and adopted.

The Librarian's report was presented by H. Piers, showing that 1,412 books and pamphlets had been received through the exchange-list during the year 1927; and 1,073 have been received during the nine months, January to September, 1928. The total number of books and pamphlets received by the entire Provincial Science Library (with which that of the Institute is incorporated) during 1927 was 1,667. The total number in the Science Library on the 31st December, 1927, was 74,977. Of these, 56,416 (about 75 per cent.) belong to the Institute, 18,440 to the Science Library proper, and 121 to the Hugh Fletcher Memorial Library. 140 books were borrowed in 1927, besides those consulted in the Library. In 1928 the Science Library again received a grant of $500 from the Provincial Government, for the purchase of books on pure and applied science and the trades, as well as for binding. With this grant, 43 recently published works have been added to the Library, and 15 volumes of Proceedings of the Royal Society of London have been bound. The report was received and adopted. At the request of the meeting Mr. Piers read a list of the authors and titles of the books which had been purchased.

The Corresponding Secretary, Prof. D. S. McIntosh, reported that he had sent out 309 circular letters in connection with the revision of the exchange-list. About 134 replies had been received. About 19 of the institutions, which had been applied to, did not desire to exchange publications with this society. Some 44 new names were to be added to the exchange-list on cards which had been prepared. The report was received and adopted.

The Science Exhibition Committee reported through its chairman, Dr. D. McIntosh, that it had decided to hold the exhibition on the 23rd and 24th of November in the Medical Science Building, College Street, and the Science Building, Studley. Admission would be free. The report was received and adopted.

The Editor, Dr. MacKay, reported that the papers presented at the last session had been printed, and the printing of the Proceedings would complete the part (Vol. 17, pt. 2).

On motion of Mr. Piers and Dr. Bronson, a vote of thanks was presented to Dr. MacKay for his services as editor.

It was announced that John G. Allen of the Cable SS. "John MacKay," Halifax, had been elected an ordinary member on the 1st of October.

Dr. Ritchie, Dr. Bronson, and Prof. Nickerson were appointed a nominating committee, and on their report the following were elected officers for the ensuing year, 1928-29:—

President,—PROF. DOUGLAS MCINTOSH, D.SC., F.R.S.C., *ex-officio* F.R.M.S.

First Vice-President,—PROF. ELRID GORDON YOUNG, PH.D.

Second Vice-President,—PROF. DONALD SUTHERLAND MCINTOSH, M.SC.

Treasurer,—DONALD J. MATHESON, B.SC.

Corresponding Secretary,—H. RITCHIE CHIPMAN, PH.D.

Recording Secretary and Librarian,—HARRY PIERS.

Councillors without office,—A. H. MACKAY, LL.D., F.R.S.C., PROF. H. S. KING, PH.D., PROF J. N. GOWANLOCH, B.A., B.SC., A. G. HUNTSMAN, M.B., F.R.S.C., (succeeded on 7th Jan., 1929, by A. H. LEIM, PH.D.), DEAN G. A. BURBIDGE, PROF. W. F. MCKNIGHT, B.SC., and R. P. SMITH, M.B., C.M.

Auditors,—P. R. COLPITT and PROF. W. P. COPP, B.A., B.SC., M.E.I.C.

On motion of Mr. Piers and Dr. Young a vote of thanks was presented to the retiring president, Dr. Johnstone.

FIRST ORDINARY MEETING.

Medical Science Building, Halifax.
14*th November*, 1928.

The President, Dr. McIntosh, in the chair. Attendance 21.

It was announced that Melville Cumming, B.A., LL.D., Halifax, and R. F. Dimmitt, B.A., Dartmouth, had been elected ordinary members, and Gordon F. Frame, B.A., Truro, an associate, on the 5th of November.

On motion of Dr. Bronson it was resolved that abstracts of all papers intended for submission to the Institute be laid before the Council prior to any decision being made as to placing their titles on the program of a future ordinary meeting.

On motion of Mr. Piers and Dr. Bronson it was resolved that authors of papers appearing solely in abstract in the Institute's Proceedings and Transactions, but published entire in other journals, should furnish the Institute's editor with full references to such places of publication, as soon as that information is available, in order that these references may appear with the printed abstracts.

On motion of Prof. McIntosh it was resolved that an abstract be printed at the beginning of each paper published in full in the Institute's Transactions.

The following papers were presented:—

(1) Two Simple Methods of Purifying Radium Emanation.—By W. G. Moran, B.Sc., Dalhousie University, Halifax, N. S.

Abstract.—A simple apparatus for the purification of radium emanation has been devised and put in operation at the Victoria General Hospital, Halifax, N. S. The method is low in cost and easy in operation. The use of liquid air is avoided and the removal of water vapor found unnecessary. Two different methods of purification have been developed.

One method ignites the oxygen and hydrogen with a hot copper oxide filament which also oxidizes the excess hydrogen. The other method uses a spark to unite the oxygen and hydrogen while the excess hydrogen passes through the walls of a heated palladium tube into the outside air. The emanation is pumped from the solution into the single small purifying tube and from there pushed directly up into the thin walled capillary. The emanation may be withdrawn and collected over mercury at any stage in the purification. The concentration attained compares favorably with the results obtained with much more complicated installations.

Published in full, Phil. Mag., [7], 7, 399-404 (1929).

(2) Intestinal Reactions to Drugs in Different Fishes.—By Prof. N. B. Dreyer, M. A., M.R.C.S. (See Trans., p. 199).

(3) The Effect of Velocity on Diffusion Rates: Preliminary Report.—By A. E. Murray, B.A. (See Trans., p. 168).

SECOND SCIENCE EXHIBITION.

Medical Science Building, College St., and Science Building, Studley, Halifax.
23rd and 24th November, 1928.

The great success which had attended the Institute's Scientific Exhibition of November 1926 induced it to hold another and larger one in the present year, on the 23rd of November from 8 to 10 p. m., and on the 24th of November from 3 to 5 and 8 to 10 p. m. The biological exhibits were shown in the Medical Science Building, and the remainder in the Science Building, Dalhousie University.

Among those who assisted were the various departments of Dalhousie University and of King's College, Maritime College of Pharmacy, N. S. Technical College, Fisheries Experimental Station (Atlantic), Dominion Government Laboratory, Pathological Institute, and many industrial organizations. Students of the universities were particularly helpful in installing the exhibits and assisting in demonstrating them to visitors. Two printed guides were on sale. Admission was free.

The exhibition again proved to be exceedingly popular, the rooms being always crowded with interested visitors of all classes. The attendance at the Medical Science Building was estimated at about 3,500, and at the Science Building about 2,500, making a total of 6,000.

SECOND ORDINARY MEETING.

Medical Science Building, Halifax.
10th December, 1928.

The President, Dr. McIntosh, in the chair. Attendance 17.

It was announced that W. E. Jefferson, B.Sc., Halifax, had been elected an ordinary member, and Prof. H. E. Bigelow, Ph.D., Mt. Allison Univ., Sackville, N. B., an associate member, on the 3rd of December.

The following demonstrations of apparatus were then presented:

(1) A New Form of Liquid Extractor.—By PROF. E. G. YOUNG, PH. D.

(2) A Method of Determining Small Quantities of Lactic Acid.—By PROF. E. G. YOUNG, PH. D.

(3) Artificial Heart.—By PROF. O. S. GIBBS, M.B., Ch.B.

(4) New Apparatus Used in Filtering.—By PROF. D. MCINTOSH, Ph. D.

The President, as chairman of the recent Science Exhibition, presented a report thereon. The receipts from the sale of guides were $209.55, and the expenditures $235.90, causing a deficit of $26.35. In the discussion which followed, the prevailing opinion seemed to be that the effort associated with the preparation and demonstrations was so great that it appeared inadvisable to undertake another exhibition for some time.

THIRD ORDINARY MEETING.

Medical Science Building, Halifax.
14th January, 1929.

The President, Dr. McIntosh, in the chair. Attendance 14.

It was announced that the following had been elected members on the 7th of January: Prof. D. U. Hill, Ph.D., Acadia Univ., Wolfville; Lt.-Com. F. L. Houghton, R.C.N., Admiralty House, Halifax; Prof. Richard Hamer, Ph.D., Acadia Univ., Wolfville; Prof. Roy Fraser, B.S.A., M.A. Mt. Allison Univ., Sackville, N. B.; Prof. Henry B. Bigelow, Ph.D., Museum of Comparative Zoology, Harvard Univ., Cambridge, Mass.; Miss Elizabeth G. Frame, B.A., Dalhousie Univ., Halifax; Prof. H. G. Perry, D.Sc., Acadia Univ., Wolfville; Prof. Muriel V. Roscoe, Ph.D., Acadia Univ., Wolfville; and George A. Edwards, M.I.R.E., Halifax.

The following papers were presented:—

(1) The Heats of Solution of Certain Alkali Halides and the Specific Heat of their Solutions.—By F. M. G. JOHNSON, PH.D., F.R.S.C., OTTO MAASS, PH.D., F.R.S.C., and H. RITCHIE CHIPMAN, PH.D., F.C.I.C. (See Trans., p. 149).

(2) Effect of Storage Temperature on Expressible Juice in Frozen Fish.—By A. H. Leim, Ph.D., Fisheries Experimental Station (Atlantic), Halifax, N. S.

Abstract.—The results to be reported are the recent ones from experiments begun by Messrs. D. A. MacFayden and H. R. Wyman at the Fisheries Experimental Station. The problem is to ascertain the optimum temperature for the storage of fish when frozen. The amount of juice expressed from a known weight of fish under constant conditions is taken as a measure of the destruction of tissues which has occurred in storage. After six months' storage at various constant and fluctuating temperatures (-5 to -20°C.) it is found that the amount of expressible juice is about 40% of the original weight for fish stored at -5° while it is about 23% for those stored at -20°. For freshly frozen material the amount is from 10 to 12%.

Fourth Ordinary Meeting.

Medical Science Building, Halifax.
13*th February*, 1929.

The President, Dr. McIntosh, in the chair. Attendance 19.

It was announced that the following had been elected ordinary members on the 4th of February: Prof. Norman J. Symons, M.A., King's College; Miss Anna M. Wilson, M.Sc.. Fisheries Experimental Station (Atlantic); John C. Hall, M.Sc., Tower Road School; and John L. Greenham, B.Sc., of Moirs' Ltd.; all of Halifax

The following papers were presented:

(1) Some Measurements of the Heat Capacity of Fish Muscle.—By H. Ritchie Chipman, Ph.D., and George O. Langstroth, B.A., Fisheries Experimental Station(Atlantic). (See Trans., p. 175).

(2) An Attempt to Measure the Range of Alpha Particles from Thorium.—By J. L. Nickerson, M.A., Dalhousie Univ. (See Trans., p. 172).

(3) A New and Accurate Drop Recorder.—By Prof. O. S. Gibbs, M.B., Ch.B., Department of Pharmacology, Dalhousie Univ., Halifax, N. S.

Abstract.—The instrument consists of three parts:
(1) Displacement chamber similar to one previously described;[1]
(2) Suction electrodes;
(3) Vacuum chamber and sulphate reservoir combined.

The fluid to be measured enters the displacement chamber and forces an equivalent amount of sulphate to the lower electrode. As it wells up it makes contact with the upper suction electrode, and is immediately carried away. The contacts are recorded in any convenient way. The instrument as shown will record 600 drops per cc. Full details will be published at a later date.

(1) O. S. Gibbs. Journ. of Lab. and Clin. Med. 1927 XII, p. 686. Published in full, Science, LXIX, 649-50 (June 21, 1929).

FIFTH ORDINARY MEETING.

Medical Science Building, Halifax.
13*th March*, 1929.

The President, Dr. McIntosh, in the chair. Attendance 27.

It was announced that the following had been elected ordinary members on the 4th of March: Clyde Marshall, M.D., C.M.; Mrs. Frances B. Marshall, Ph.D., and Prof. E. W. H. Cruickshank, M.D., D.Sc., Ph.D., all of Halifax.

The following papers were presented:

(1) *Ichthyophonus Hoferi*, Plehn and Mulsow, a Flounder Parasite New to North American Waters.—By MISS MARJORIE F. ELLIS, B. A. (See Trans., p. 185).

(2) The Endocellular Enzymes of *B. coli communis.*—By PROF. E. GORDON YOUNG, PH.D., Department of Biochemistry, Dalhousie University, Halifax, N. S.

Abstract.—Emulsions of *B. coli communis* have been prepared from stock cultures by growth on nutrient agar attaining concentrations of about 5×10^{12} cells per ml. These cells have been destroyed by repeated freezings and thawings over a period of several hours, cellular debris centrifuged off and the cellular extract passed through a Berkefeld candle. This liquid has been tested for its enzymic activity on certain substrates. It hydrolyses peptone at pH 7-8. It does not decompose glucose in the absence or presence of phosphate. It possesses a dehydrogenase acting on succinic acid anaerobically as shown by the Thunberg technique with methylene blue.

Correlating studies of cell death by the freezing technique with rate of methylene blue decolorization have shown that dehydrogenase activity on succinic acid and formic acid is independent of cell concentration but associated with cell stroma. Dehydrogenase activity on acetic acid, lactic acid, alcohol and glucose is destroyed by the freezing technique. Toluene has been shown to act identically. All oxidative mechanisms can be shown to be independent of living cell concentration temporarily.

Published in full, Biochem. J., **23**, 831-9 (1929).

The President exhibited a new form of overflow siphon.

SIXTH ORDINARY MEETING.

Medical Science Building, Halifax.
15*th April*, 1929.

The President, Dr. McIntosh, in the chair. Attendance 19.

The President reported that the members of the Council had decided to tender a complimentary dinner and also make a presentation of a piece of plate to Dr. A. H. MacKay, as tokens of the Institute's respect, on the 11th of May, and that a circular to that effect and asking for subscriptions had been sent on the 9th inst. to all members.

On motion of Prof. Gowanloch and Dr. Johnstone it was resolved that the N. S. Institute of Science record its expression of sorrow at the passing of Mr. W. Stewart Allan, who was for two years a member of the Institute. His death by drowning, while engaged in biological investigations in the Gulf of Mexico, cut short a career that held high promise of achievement in his chosen field.

The following papers were presented:

(1) *Ascophyllum nodosum*, Le Jolis: A Study of its Gross Morphology.—By MISS CONSTANCE I. MACFARLANE, Department of Botany, Dalhousie University, Halifax, N. S.

Abstract.—Collections of *Ascophyllum nodosum*, Le Jolis, taken throughout the whole year were studied. The receptacles appear in February, and take 18 months to develop. The air bladders develop one each year, appearing in April. The fastest growth is during the summer.

(2) The Reduction of Metanitrobenzaldehyde with Sodium Arsenite.—By PROF. H. E. BIGELOW, PH.D., and MISS JEAN H. PHILP, Mt. Allison Univ., Sackville, N. B. (See Trans., p. 193).

(3) An Adiabatic Calorimeter for Low Temperature Measurements.—By D. LEB. COOPER, M. Sc., and PROF. D. MCINTOSH, D. Sc. (See Trans., p. 197).

SEVENTH ORDINARY MEETING.

Medical Science Building, Halifax.
15*th May*, 1929.

The President, Dr. McIntosh, in the chair. Attendance 17.

The President announced that, owing to the serious illness of Dr. A. H. MacKay, the complimentary dinner and presentation to him in recognition of his services in the cause of science and education in this Province, which had been arranged for the 11th inst., had been postponed. Deep regret was expressed at his illness.

The following papers were presented:—

(1) Autolytic and Bacterial Decomposition of Haddock Muscle at Low Temperature above Freezing.—By Ernest Hess, M. A., Fisheries Experimental Station (Atlantic), Biological Board of Canada.

Abstract.—The influence of temperature upon autolytic and bacterial decomposition of haddock muscle within the range of +2.2 to -1.1° C. (36 to 30° F.) has been followed by determining the increase in the amount of volatile basic nitrogen parallel with the increase in the number of bacteria. A mixed flora of bacteria normally occurring on haddock was used for inoculation purposes. The experimental results show that practically no autolysis takes place at these temperatures, and that the bacterial decomposition and bacterial growth rate at -1.1°C is only about half of that at +2.2°C. Expressed in mathematical terms, it was found that the temperature coefficients (Q_{10}) for these reactions during the phases of logarithmic increase were considerably higher than the values for Q_{10} for ordinary life processes at medium temperatures ($Q_{10} = 2 - 3$, Van't Hoff). The values for Q_{10} increased rapidly with decreasing temperature range.

The practical application of these findings has been demonstrated to be of economical importance in the holding of fresh fish at -1.1°C, instead of the customary holding in crushed ice at about +2.2°C.

(2) Artificial Heart (Demonstration of Apparatus).—By Prof. O. S. Gibbs, M.B., Ch.B., Department of Pharmacology, Dalhousie University, Halifax, N. S.

Abstract.—As was previously reported to the society, experiments are being conducted in the maintenance of a complete circulation in the cat by means of a mechanical heart. The method at that time was unsatisfactory and has now been improved. Briefly it is as follows:

Blood from the heart flows through a light valve into a rubber bellows, on the other side of which is another valve of a different design suited to stand high pressures. Two such devices are enclosed in a brass box. Attached to each rubber bellows is a small moveable switch which is opened and closed by the movement of the bellows, the distance being controlled

by a single screw in each case. This apparatus is connected to a water supply at a pressure of twenty pounds per square inch by means of an electrical valve similar to one previously described. The apparatus contains an electrical heater and thermometer. As the blood flows into the bellows it expands and at a predetermined time makes contact, thus activating the electric valve and so turning on the water pressure. In this way the bellows are squeezed and the blood forced onwards. When the bellows are fully closed, the current is cut off and the valve opens. As the water drains, it exerts a slight suction on the bellows, helping them to fill again. The extent of this suction is controlled simply by the length of the outlet pipe. The two heart chambers are connected electrically so that both must fill before the valve is closed. In order to insure proper emptying the systemic chamber which works against much higher pressure is made the master of the electrical switch. The apparatus as shown works very comfortably at a speed of over two hundred beats per minute and against a pressure of well over 200 mm Hg. Simplicity of device has been aimed at in order to facilitate cleaning and repairing. An attempt has been made also at constructing the apparatus in a robust form so that accidental stoppage is minimized. In use, the apparatus is filled with warm gum ringer which appears all that is necessary for satisfactory use on a cat without the addition of extra blood.

Owing to the fact that slow records are frequently demanded and at this speed the heart beats as recorded are indistinguishable, a device is fitted to the valve which records only one beat in ten. Full details of this apparatus and its applications will be published in the Journal of Pharmacology and Experimental Therapeutics, 1930.

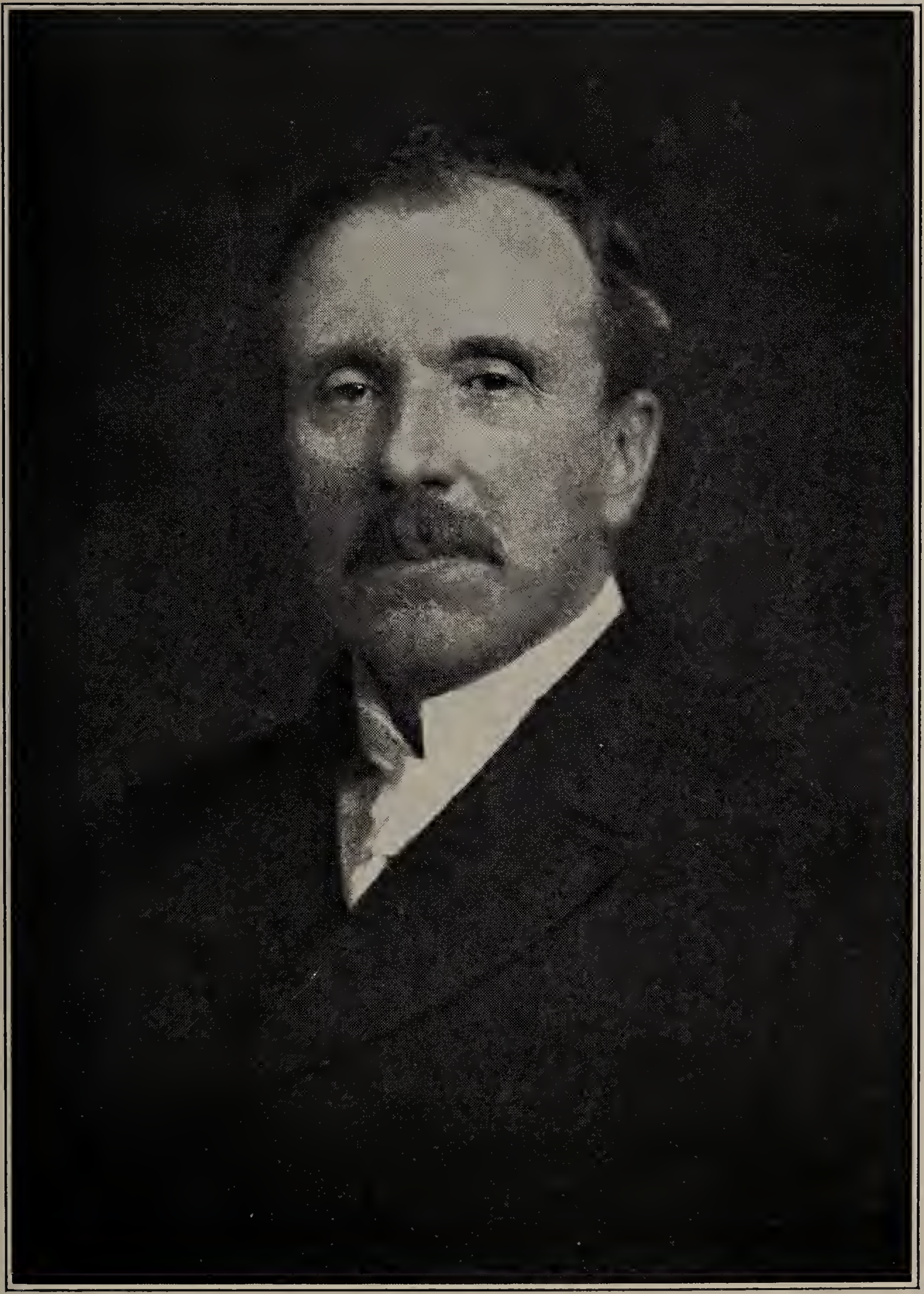
(3) Solubility of Uric Acid.—By PROF. O. S. GIBBS, M.B., CH.B., Department of Pharmacology, Dalhousie University, Halifax, N. S.

Abstract.—It has been recently found that the gel form of uric acid as prepared by the technic of Schrade and Boden can be obtained in a dried form by precipitating a concentrated solution by means of acetone or absolute alcohol, the precipitate being dried in vacuo. The resulting material is freely soluble in distilled water. It has also been discovered that a similar form of uric acid occurs in the fowl's blood.

Published in full in Science, Vol. LXX, pp. 241-242 (Sept. 6, 1929).

(4) On the Rate of Freezing in Fish Muscle.—By GEORGE O. LANGSTROTH, B.A. (See Trans., p. 206).

HARRY PIERS,
Recording Secretary.



Yours very truly,

A. H. MacKay

PROCEEDINGS

OF THE

Nova Scotian Institute of Science

SESSION OF 1929-30
(Vol. XVII, Part IV)

68TH ANNUAL BUSINESS MEETING.

Dalhousie Medical Science Building, Halifax,
9th October, 1929.

The President, Dr. Douglas McIntosh, in the chair.

Other members present: Dr. E. G. Young, Prof. D. S. McIntosh, D. J. Matheson, Dr. H. R. Chipman, Dr. H. S. King, Prof. G. A. Burbidge, Dr. A. H. Leim, Dr. J. H. L. Johnstone, Dr. S. G. Ritchie, G. A. Sandoz, Dr. E. W. H. Cruickshank, Dr. R. Hamer and H. Piers.

The President delivered the opening address as follows:

In that admirable document, the Constitution of the Nova Scotian Institute of Science, under the heading "Duties of the Officers and Council," these lines are found:

> "The President shall, if he sees fit, deliver at the annual business meeting of the Institute an address reviewing the progress of the Institute during the year; giving a short sketch of the life and scientific work of members deceased during the year, and treating such other topics as he may deem conducive to the welfare of the Institute and the promotion of its objects."

Each President, as far as I am aware, has seen fit to shoulder the implied obligation and, in a brief address, has commented on matters affecting the Society during his year of office. The privilege of integrating our losses and gains is one which I value too highly to forego.

For the first time in several years, we mourn the removal of members by death, for two, Dr. A. H. MacKay and W. Stewart Allen, have passed on.

Dr. MacKay, a past President of this Society (1899-1902), its most distinguished and almost our oldest member, filled a unique place in the community, and as Superintendent of Education, influenced in a direct way the lives of generations of Nova Scotians. Coming to the Education Office, after building up Pictou Academy to the position of the first school in Nova Scotia, as the appointee of a political party to which he did not belong, which, in Nova Scotia at least, marks his intellectual stature as nothing else could, he spent a long life in the service of education and science. Due to him, science occupies a place in the curriculum of our schools; while his original work in zoology and his activity as Instructor in Biology at Dalhousie made him known and honoured amongst the students of his own science. During his whole lifetime in Halifax he exerted himself in the furtherance of the aims of this Institute, and for many years acted as our editor, an office necessitating almost infinite patience and tact. His last active work had to do with our Transactions, and letters to members contributing papers were sent out but a few days before his death. The lines to Marmion are hardly out of place in expressing his relation to the work of this society: "He died a gallant knight, his sword in hand." A resolution, to be placed on our records, by one who enjoyed his friendship for many years, will be moved later in the evening.

W. Stewart Allen, a young biologist of promise, met a tragic death while on scientific work in the Gulf of Mexico. Those well acquainted with the deceased unite in praising his qualities of heart and mind. While the passing of a member who has exceeded the span of life allotted to us by the Psalmist is to be deplored, far sadder is the death of one just entering into scientific life, "who dies not knowing how the day has gone." Suitable action was taken by the Society in the case of the deaths of both these members.

The Transactions for 1927-28 were issued in good time, but those for the past year will be delayed,—indeed it may be necessary to ask some of those who contributed papers during our last session for duplicate copies. Dr. King has been requested by the council to take the onorous post of editor, and Messrs. Johnstone, Young and Chipman to act with Dr. King as a committee of publication. All these gentlemen have agreed to serve, and I ask you to assist in making their difficult work as light as possible.

Our ordinary meetings were, I venture to think, remarkably successful, and the papers read were of a high order of merit; one indeed excited an interest far outside this Province. Sixteen papers were contributed, a number of pieces of new apparatus were shown and several new methods of work demonstrated. It is a little difficult to classify our papers, as many are in the borderland between two sciences, indeed some are in a circle circumscribed by several sciences. Roughly, seven might be catalogued as physical or chemical, four were on fish treatment, two on pharmacological subjects, two on bacteriology and one on botany. To our new members I may say that one aim of the Institute is to have in its Transactions a record of all original work done in Nova Scotia, and that this does not preclude publication in journals devoted to special branches of science.

I believe our society is to be congratulated on the high standard of its meetings, and that those who attended have benefitted both from the papers and the free discussions.

If new members be taken as the sole mark of progress the past year must be looked on as a banner year in our history, for no fewer than twenty-one associate and ordinary members have been placed on our rolls for the first time, and our corresponding, associate and ordinary members now number approximately one hundred and twenty. A fair proportion of these are from sister universities, and the suggestion has been made that we should, from time to time, hold meetings outside of Halifax. This matter will come up for consideration during the coming year.

The Science Exhibition brought our society into the public eye, and it may not be amiss to repeat a part of the report of the Exhibition Committee:

> "Approximately twenty-five hundred persons attended at Studley, and thirty-five hundred at least at the Medical Science Building. The exhibition, under the patronage of the Lieutenant Governor of Nova Scotia, was supported by the governors, students and staff of Dalhousie, by the press, and by many manufacturers, such as Moirs, the Nova Scotia Light and Power Company, the Maritime Telegraph and Telephone Company, the Imperial Oil Company, Birks and Sons, Eatons, the Eastern Hosiery Company, the Canadian Carbonate Company, the Canadian Liquid Air Company, etc.
>
> The total receipts from the sale of programmes were $209.55; while the expenditures were $235.40, leaving a deficit of $26.35, which was paid out of the funds of the Institute. It should be emphasized that all material received from Dalhousie University was paid for, so that the only direct expense borne by the College was for the lighting. Programmes, invitations and gratuities made up almost two-thirds of the expenses."

There is a wide diversity of opinion amongst our members as to the value of these exhibitions. Many hold that the expenditure of time and energy far outweighs any benefit derived by this society or by science in general. While I do not accept this view, it must be admitted that the labour entailed is too great to undertake another exhibition without serious consideration.

During the past two years, three of our members, Dr. Young, chairman, and Professors Johnstone and King, have revised our exchange list, which had become somewhat obsolete. The thanks of the Institute are richly deserved by these three gentlemen who gave ungrudgingly so much time to this revision. The Science Library is benefitting and will benefit from their efforts.

A committee, consisting of Dean Burbidge and Dr. Johnstone, has discussed with the council a more satisfactory method of addressing our Transactions and the monthly notices of our meetings. A decision on this important matter has not yet been made.

The Nova Scotian Government has continued the $500 grant to the library, and it is becoming daily of more value to the general public. While the library is a government institution, it has benefitted in the past by the exchange of the Institute's Transactions for those of other learned societies. Mr. Piers, however, will report on its conditions, and give an account of the recent accessions.

In closing this superficial review of the year's activities, I wish to express my thanks to the members for the honour they have done me in electing me President, and to the council and members for their support in all our undertakings. Let us endeavour to make the meetings of this session as successful and enjoyable as those held during the past year.

The Treasurer's report was presented by D. J. Matheson, showing that the receipts for the year were $2,413.59; the expenditures, $1,076.04; balance in hand (in current account), $1,337.55; and the balance at credit of reserve fund, $201.22; while the permanent endowment fund is $1,500.00. The report was received and adopted.

The Librarian's report was presented by H. Piers, showing that 1,382 books and pamphlets had been received through the exchange-list during 1928; and 1,246 have been received during the nine months, January to September, 1929. The total number of books and pamphlets received by the entire Provincial Science Library (with which that of the Institute is incorporated) during 1928, was 1,692. The total number in the Science Library on the 31st of December, 1928, was 76,669. Of these, 57,798 (about 76 percent) belong to this Institute, 18,717 to the Science Library proper, and 154 to the Hugh Fletcher Memorial Library. 142 books were borrowed in 1928, besides those consulted in the Library. A grant of $500 has been again placed by the Provincial Government to the Library's credit, and with this have been purchased a number of the latest books on pure and applied science and the trades, and some additional volumes of the Proceedings of the Royal

Society of London have been bound. The report was received and adopted.

The Corresponding Secretary's report was presented by Dr. H. R. Chipman. During 1928 circular letters had been sent by Prof. McIntosh, then corresponding secretary, to societies and institutions in order to revise our mailing-list, and considerable correspondence resulted. Over 200 back numbers of the Transactions had been sent out, and more than 200 invitation cards for the Science Exhibition had been mailed. The report was received and adopted.

Mr. Piers spoke feelingly and at some length regarding the lamented passing of Dr. A. H. MacKay, who had been a member of the Institute for fifty-four years and also its president. The speaker sketched that gentleman's eminent attainments as an educationist and biologist which had made his name known in both America and Europe. He also possessed fine qualities of heart which endeared him to his many friends.

The following resolution, moved by Mr. Piers and seconded by Dr. Hamer, was then passed unanimously.—

Resolved that the Nova Scotian Institute of Science, at its annual meeting held at Halifax, N. S., on the 9th of October, 1929, place on record its deep sense of the irreparable loss it has sustained through the death at Dartmouth, on the 19th May last, his eighty-first birthday, of its distinguished member and former president, Alexander Howard MacKay, B. Sc., LL.D., F.R.S.C., etc., late Superintendent of Education for the Province of Nova Scotia. He joined the Institute as an associate member on 11th. January, 1875; became an ordinary member on 21st October, 1885; was its president from Nov. 1899 to Nov. 1902; its corresponding secretary, 1902 to 1911; and editor of its Transactions from about 1908 till his death.

The many papers he published in the Institute's Transactions, as well as elsewhere, are learned and valuable contributions to our knowledge of various biological, but particularly botanical, subjects, and made him very widely known as one of the foremost scientific workers in Canada.

His notable career while principal of the Pictou Academy, 1873-89, and of the Halifax Academy, 1889-91, and finally as superintendent of education, 1891-1926, places him in a similarly high position among our educationists.

The Institute desires to express sincere sympathy with his family in their bereavement.

The recording secretary requested that past-presidents, who had not already done so, would send in photographs of themselves to be placed on file.

Dr. Hamer of Acadia University spoke of the good work done by the Institute and the general need of more research work throughout Canada.

Drs. Johnstone, Ritchie and Cruickshank were appointed a nominating committee and on their report the following were elected officers for the ensuing year, 1929-30:

President,—Prof. Douglas McIntosh, D.Sc., F.R.S.C., *ex-officio* F.R.M.S.

First Vice-President,—Prof. E. Gordon Young, Ph.D.

Second Vice-President,—Prof. Donald S. McIntosh, M.Sc.

Treasurer,— Donald J. Matheson, B.Sc.

Corresponding Secretary,— H. Ritchie Chipman, Ph.D.

Recording Secretary and Librarian,— Harry Piers.

Councillors without Office,—Prof. Harold S. King, Ph.D., Prof. J. N. Gowanlock, B.Sc.; Prof. George A. Burbidge; Prof. Alexander H. Leim, Ph.D.; Prof. George H. Henderson, Ph.D.; Donald J. Mackenzie, M.D., and Capt. W. F. Mitchell.

Auditors,— P. R. Colpitt and Prof. W. P. Copp, B.A., B.Sc., M.E.I.C.

FIRST ORDINARY MEETING.

Medical Science Building, Halifax.
13*th November*, 1929.

The President, Dr. McIntosh, in the chair. Attendance 23.

It was announced that S. Bateson, H. M. Chisholm, S. A. Beatty, B.A., J. R. Sanborn, B.Sc., Ph.D., and J. H. Mennie, M.A., B.Sc., Ph.D., the three last of the Fisheries Experimental Station (Atlantic) had been elected ordinary members on the 4th of November.

The following papers were presented:—

(1) Investigations on the Protozoan Fish Parasites of the St. Andrew's Region.—By Marjorie F. Ellis, B.A. (See Trans., p. 268).

(2) An Attempt to Demonstrate the Existence of Short Range Alpha Particles from Radium C.—By Prof. G. H. Henderson, Ph.D., and J. L. Nickerson, M.Sc. (See Trans., p. 256).

(3) The Effect of Pituitary on the Bird.—By R. Morash, Department of Pharmacology, Dalhousie University, Halifax, N. S.

Abstract.—An investigation has been conducted with the object of throwing further light on the depressor action produced by pituitary on the blood pressure of birds. Experiments were firstly directed to ascertaining the peripheral changes wrought by the separated pituitary products which were generously supplied by Dr. Kamm of Messrs. Parke, Davis and Co. The results of this work show quite clearly that the alpha or oxytocic fraction is much more powerfully depressant than the beta or vasopressin. Furthermore that the beta fraction contains a pressor substance which in some cases may produce pure rise of pressure.

Pressure changes can be largely explained by alterations in the peripheral vessels, as shown by direct blood flow measurement, and confirmed by pletysmograph tracings.

A few experiments conducted on the exposed heart in situ gave no definite evidence of a direct effect. As these experiments are not complete they do not eliminate a direct cardiac action.

Owing to the similarity of the pressure reactions to choline and especially to acetyl choline, efforts were directed to ascertain if this substance be responsible. Atropine in large doses practically obliterates the choline reaction and has little effect on either pituitary substance. This eliminates choline, but as the same does not hold true for acetyl choline, a comparison of the effects of alpha and beta pituitary, choline, acetyl choline and histamine were made on the oviduct, and the isolated intestine.

The results of this work made it quite clear that the depressor compound present in both pituitary fractions is not acety, choline, choline, or histamine. This conclusion is further supported by the fact that repeated doses of the alpha fraction lead to a temporary loss of reaction not produced by either of the cholines, or histamine.

The pressor reaction which can be obtained with beta pituitary and which is due to a peripheral vascular contraction, and associated with a marked blanching of the comb and wattles, is possibly homologous with the typical pressor reaction obtained in mammals. This is supported by the ready desensitization of the bird to this reaction.

This work was made possible by the award of a junior National Research Scholarship, and was conducted under the supervision of Professor O. S. Gibbs. Full details of this work will be published.

Demonstrations were given as follows:

(1) The Latest Model of an Artificial Heart.—By Prof. O. S. Gibbs, M.B.

(2) A Sensitive Test for Mercury.—(3) A New Reagent for Carbon Dioxide Determination.—By Prof. Douglas McIntosh, D.Sc.

SECOND ORDINARY MEETING.

Medical Science Building, Halifax.
9th December, 1929.

The President, Dr. McIntosh, in the chair. Attendance 27.

It was announced that Warren J. Duchemin, B.A., J. Clement Young, B.A., and C. W. Startup, B.Sc., of Dalhousie

University, had been elected ordinary members on the 2nd of December.

The following papers were presented:—

(1) The Variation of Dielectric Constant with Frequency. —By Prof. J. H. L. Johnstone, Ph.D. and John Warren Williams, Ph.D.

Abstract.—Measurements of dielectric constants were made of solutions of nitro-benzene and para-dichlorobenzene in mineral oil of high viscosity at three concentrations. A decrease in dielectric constant of nitrobenzene with increasing frequency is found. Para-dichlorobenzene shows no dispersion effect. An approximate value of the relaxation time for nitrobenzene is calculated from the Debye formula after corrections are made for molecular associations. The diameter of the nitrobenzene molecule calculated from it is of the right order of magnitude.

Published in full, *Phys. Rev.*, **34,** 1483-90(1929).

(2) The Source of the Ammonia Formed in the Autolysis of Fish Muscle.— By S. A. Beatty, B.A., Fisheries Experimental Station (Atlantic), Halifax, N. S.

Abstract.—Juice was pressed from fresh muscle, and the amide nitrogen and ammonia determined. The muscle plasma was then allowed to autolyse under toluol for periods of three to five days, when the amide nitrogen and ammonia were again determined. The rise in ammonia was found to equal the decrease in the amide nitrogen.

(3) A Study of the Nutritional Requirements of Canadian College Students.— By Prof. E. Gordon Young, Ph.D., Department of Biochemistry, Dalhousie University, Halifax, N. S.

Abstract.—From the analysis of the daily muscular activity of a group of one hundred and seventy-two Canadian medical male students the energy output has been determined to average 2592 Calories per day. The average weight was 155.5 lbs. and the average age was 22 years for this group.

From the analysis of the daily diet the average energy intake was 2808 Calories. The distribution between the groups of foodstuffs was 100 gms. protein, 116 gms. fat, 328 gms. carbohydrate; and in terms of percentage of the total calories consumed 14.6% from protein, 38.5% from fat, 47.3% from carbohydrate.

This diet is taken to be at an average level of protein intake for sedentary work compared with world standards. The fat consumption is very high. The surplus of energy of intake over output of 216 Calories represents 8.5% and is notably low.

The scarcity of Canadian dietary standards is emphasized.

To be published in the *Can. Med. Ass. J.*, **23,** 1930.

Prof. H. S. King, Ph.D., then gave demonstrations as follows: (1) An Analytical Test for Sodium; (2) Apparatus for Thermal Diffusion; (3) Some Rare Inorganic Elements and Compounds.

THIRD ORDINARY MEETING.

Medical Science Building, Halifax.

13*th January*, 1930.

The President, Dr. McIntosh, in the chair. Attendance 14.

The following papers were presented.—

(1) The Edema of Para-Phenylenediamine.—By Prof. O. S. Gibbs, M.B., Ch.B. (See Trans., p. 238).

(2) The Preparation of Absolute Ethyl Alcohol.—By Prof. E. Gordon Young, Ph.D. (See Trans., p. 248).

(3) Notes on the Specific Gravities of Liquid and Solid Sulphuric Acid.—By Prof. Douglas McIntosh, D.Sc. (See Trans., p. 259).

FOURTH ORDINARY MEETING.

Medical Science Building, Halifax.

12*th February*, 1930.

The President, Dr. McIntosh, in the chair. Attendance 28.

It was announced that A. S. McFarlane, B. S. A., Halifax, had been elected an ordinary member on the 3rd of February.

The President reported that the Proceedings and Transactions for 1928-29 (vol. 17, part 3) had come from the press.

The following papers were presented:—

(1) The Acadian-Newfoundland Earthquake.—By Prof. D. S. McIntosh, M.Sc. (See Trans., p. 213).

(2) The Acadian-Newfoundland Earthquake of November 18, 1929.—By Prof. J. H. L. Johnstone, Ph.D. (See Trans., p. 223).

(3) Transient Electric and Magnetic Disturbances Accompanying the Seismic Waves of the Recent Newfoundland Earthquake.—By Prof. Richard Hamer, Ph.D., Acadia University, Wolfville, N. S.

Abstract.—Some evidence is presented that transient electric waves were associated with the Acadian-Newfoundland earthquake. The geophysical basis for such electrical tremors is discussed and a new method for locating the epicentre of an earthquake is indicated.

(4) Some Chemical Aspects of Marine Algae.—By Margaret R. Butler, B.A., Department of Biochemistry, Dalhousie University, Halifax, N. S.

Abstract.—Several species of algae common to the North Atlantic Coast have been analysed for their content of moisture, ash, potassium, iodine, protein and crude fibre.

Moisture determinations on nine species were found to average 80%, with a maximum of 91% and a minimum of 68%.

Ash determinations average 25% of the dry weight; maximum in *L. longicruris* of 33.2%, minimum in *P. laciniata* of 15.7%.

Potassium determinations on six species gave an average content of 5.57% of the dry weight; maximum in *R. palmata* of 12.22%, minimum in *P. laciniata* of 2.69%.

Iodine has been determined in twelve species the average content of which is less than 0.1% of the dry weight. The maximum of 0.349% was found in *L. digitata*, a minimum of 0.0085% in *P. laciniata*.

Nitrogen determinations were made on six species, three of which were much higher than the others, and calculated as protein (N x 6.25) would average 22.6%.

Crude fibre determinations were made on six species and only one found to be above 5%; the majority are less than half of this amount.

To be published in Plant Physiology, **6**, 1931.

Fifth Ordinary Meeting.

Medical Science Building, Halifax.
17*th March*, 1930.

The President, Dr. McIntosh, in the chair. Attendance 18.

Mr. Piers presented a list of books purchased in 1929 for the Provincial Science Library.

The following papers were presented:—

(1) Colloidal Uric Acid.—By Prof. E. Gordon Young, Ph.D., and F. F. Musgrave, B.A., Department of Biochemistry, Dalhousie University, Halifax, N. S.

Abstract.—A study has been made of the conditions under which uric acid will form a gel in aqueous solution. The influence of supersaturation, of temperature and of hydrogen ion concentration are all shown as important factors. The hydroxides of sodium, potassium and lithium form with uric acid more or less stable gels within limiting conditions. This power of gel formation is also possessed by numerous organic bases, especially the lower alkyl amines, guanidine, hydrazine, coniine, hydroxylamine and hexamethylene tetramine. Certain of these substances can also form sols with uric acid. The colloidal nature of the complex has been determined from diffusion experiments, molecular weight determinations and microscopical observation. From quantitative estimations of solution ratios, of elementary composition and from the electrometric titration of pure uric acid, a theory is advanced to explain the colloidal behavior of uric acid in aqueous solution. Its applicability to normal physiology is demonstrated.

To be published in *J. Biol. Chem.*

(2) A Note on the Biological Assay of Tincture Digitalis—By G. A. Grant, M.Sc., and S. G. Alexander. (See Trans., p. 244).

(3) The Müller Conglobation Reaction in the Diagnosis of Syphilis.— By Zebud M. Flinn, Dalhousie Medical School, Halifax, N. S.

Abstract.—The preparation of the antigen used by Müller in his conglobation reaction is given in detail. There follows a description of the technic employed in this reaction. Comparative tables are given illustrating a series in which both the Müller conglobation test and the Kahn precipitation test were done on blood from both treated and untreated, syphilitic and non-syphilitic patients.

Published in full in *The Journal of Laboratory and Clinical Medicine*, 1930.

Sixth Ordinary Meeting.

Medical Science Building, Halifax.

14*th April*, 1930.

The President, Dr. McIntosh, in the chair. Attendance 29.

The President was appointed delegate to represent the Institute at the May meeting of the Royal Society of Canada.

The following demonstration and papers were presented:—

(1) Prof. O. S. Gibbs, M.B., Ch.B., showed motion pictures illustrating the attachment of his artificial heart to a cat, in place of the natural heart, and also illustrating the recording of the effects of the administration of certain drugs to the animal.

(2) On the Specific Heat of Tungsten, Molybdenum and Copper.—By H. L. Bronson, Ph.D., and H. M. Chisholm, Department of Physics, Dalhousie University, Halifax, N. S.

Abstract.—This investigation was undertaken in order to determine the specific heat of tungsten. This was needed for certain theoretical problems and the values obtained by previous investigators were very discordant.

A Richards adiabatic calorimeter was used for the heat measurements. The metal was heated in an electric furnace or cooled in solid carbon dioxide and dropped directly into the calorimeter, its initial temperature beign measured by a thermocouple. The apparatus and method was identical with that used by Cooper and Langstroth (Physical Review, **33**, 243, 1929) except for the design of the furnace and the measurement of the high temperature. The final temperature was in all cases about 20°C.

The measurements on molybdenum were taken to check Cooper and Langstroth's work after it was discovered that there was a large temperature gradient in the furnace used by them, thus introducing considerable uncertainty in the value of their high temperature measurements.

The International Critical Tables indicate that the value for the specific heat of copper is better known than that of most substances and it was thought to be of interest to see how the values obtained by our method would check with that in the tables.

Six measurements on the specific heat of copper between 20° and 280°C. gave the following equation:—$C_p = .0917 + .000028\ T$. This is very close to $C_p = .0914 + .000025\ T.$, obtained from the Tables.

For molybdenum we obtained from 15 measurements

$$C_p = .0597 + .000025\ T.$$

In the case of tungsten there were 35 measurements which gave

$$C_p = .01313 + .000009\ T.$$

The average deviation of the individual measurements from the above curves was about $\frac{1}{4}\%$.

The values obtained for the average specific heats between 20°C. and the temperature of solid carbon dioxide were as follows: for copper .0886, for molybdenum .0569 and for tungsten .0508. These values indicate that in all three cases the slope of the specific heat curve is greater below 20°C. than at higher temperatures.

It is our intention to carry out further measurements at still higher temperatures and to use a new calorimeter so designed as to largely reduce certain heat losses and corrections which may introduce constant errors of possibly $\frac{1}{2}\%$ in the above results.

(3) The Determination of the Amount of Gases in Liquids. —By Prof. Douglas McIntosh, D. Sc., Department of Chemistry, Dalhousie University, Halifax, N. S.

Abstract.—Dissolved gases not forming compounds with the solvent are liberated when the liquid is frozen, as there is no place for the gas molecules in the crystal lattice. The gas, if present only in small amounts, is determined by a McLeod gauge, if present in larger quantities, by removing with a Toepler pump and measuring. The liquids sealed in glass tubes are placed in a chamber from which the air is exhausted; they are then frozen at carbon dioxide temperature and the gases measured.

Water boiled until three-quarters is evaporated still contains traces of gas. The carbon dioxide is not completely removed from its solution by freezing and remelting three times, but is almost completely removed by a double distillation at a low temperature. When the method is further developed it may be useful for the analysis of liquids decomposed on boiling or heating.

(4) A Separatory Funnel for Washing Heavy, Volatile Liquids.—By Prof. Harold S. King, Ph.D. (See Trans., p. 240).

(5) Notes on the Preparation of Alkyl Iodides.—By Prof. Harold S. King, Ph.D. (See Trans., p. 242).

(6) The Possible Correlation between Sun-spot Cycle and Apple Production.—By Prof. Richard Hamer, Ph.D., Acadia University, Wolfville, N. S.

The draft of instructions or information to the writers of papers, to occupy one page of print, was read and approved.

SEVENTH ORDINARY MEETING.

Medical Science Building, Halifax.
12*th May*, 1930.

The President, Dr. McIntosh, in the chair. Attendance 23.

On motion of Dr. Henderson and Mr. Piers it was unanimously resolved that the thanks of the Institute be presented to the President for the able manner in which he has occupied the chair during his two years' term of office. Much regret was expressed at his intended departure from Halifax in the coming summer.

The following papers were presented:—

(1) Unusual Fishes and Other Forms in Nova Scotian Waters.— By Prof. A. H. Leim, Ph.D., Fisheries Experimental Station (Atlantic), Halifax, N. S.

Abstract.—In the fall of 1928 the water along the Nova Scotia coast was unusually warm from surface to bottom. Correlated with this warm water was the appearance of several species of southern fishes which rarely come so far north. The species recorded for Halifax Harbour were:

Shark sucker, *Echeneis naucrates L.*
*Filefish, *Monacanthus hispidus L.*
*Surmullet, *Mullus auratus* Jordan & Gilbert

The Fishery Officer at Liverpool, N. S., sent in specimens from his district of:

*Rudderfish, *Seriola dumerili* (Risso)
*Hardtail, *Caranx crysos* Mitchill
*Moonfish, *Vomer setapinnis* Mitchill
*Bluefish, *Pomatomus saltatrix L.*

(*) Identifications made or confirmed by Mr. W. C. Schroeder, Museum of Comparative Zoology, Cambridge, Mass.

(2) The Range of the Alpha Particles from Uranium II.— By Sydney Bateson, B.Sc., Department of Physics, Dalhousie University, Halifax, N. S.

Abstract.—By means of a scintillation method a preliminary value for the range of α particles was determined. The method was discussed. This work is being continued.

(3) The Preparation of Anhydrous Pinacol.—By Prof. Harold S. King, Ph.D., and W. W. Stewart. (See Trans., p. 262).

HARRY PIERS,
Recording Secretary.

OBITUARY NOTICE OF
ALEXANDER HOWARD MACKAY, B.A., B.Sc., LL.D., F.R.S.C.
EDUCATIONIST AND SCIENTIST
1848-1929.

BY HARRY PIERS.

Alexander Howard MacKay, one of Canada's foremost educationists and scientists, was born at Plainfield, Mount Dalhousie, a small village in a beautiful and fertile farming district of Pictou County, Nova Scotia, on 19th May, 1848, the year memorable as that in which responsible government was established in the province. He was the son of John MacKay, a sturdy native of rugged Sutherland, North Scotland, who came to this province in 1822, and his wife, Barbara (Maclean) MacKay.

He received his earlier education at old Pictou Academy, taught a rural school in 1865, and then attended the Provincial Normal School, Truro, from which he graduated in 1866. Then he entered Dalhousie College, Halifax, where in 1873 he graduated as a bachelor of arts with honours in mathematics and physics; and in 1880 he received the degree of bachelor of science with honours in biology, from the short-lived University of Halifax.

His career as an educationist virtually began in May, 1873, when he was appointed principal of the Annapolis County Academy, but in November of the same year he became principal of Pictou Academy in succession to Dr. Herbert A. Bayne, and there taught mathematics and science. Under his able and vigorous leadership the Academy revived, made phenomenal progress, and rapidly became celebrated throughout, and far beyond, the province. Pupils flocked there from all parts of the country, until there was not enough room for all, and a larger building had to be built in 1880. When the Munro exhibitions and bursaries were established in that year, for students matriculating into Dalhousie University, Pictou Academy men began to win most of these prizes. He organized the Pictou Academy Scientific Association which inspired many a young man with an ardent love of nature. During his regime the Academy probably reached the pinnacle of its efficiency and fame. Among the teachers associated with him we find such now notable names as Hector McInnes, K. C., Hon. Mr. Justice Mellish, Dr. David Soloan, and others. Many who later also rose to prominence were pupils of the Academy at this period.

In the meantime MacKay was earnestly engaged in original scientific work, and his high attainments in this respect were recognized when in May, 1888, he was elected a Fellow of the Royal Society of Canada.

In 1889 after sixteen years of marked success, he resigned from the Pictou institution to assume the principalship of the Halifax County Academy in succession to that grand old schoolmaster, Dr. Gilpin, of revered memory. There he remained but two years, when he was wisely selected as the educationist who most deserved further promotion.

On 4th November, 1891, he was appointed superintendent of education for Nova Scotia, succeeding Dr. Allison, an appointment which was greeted with universal satisfaction and commendation. In addition to his onerous official duties, he lectured in biology in Dalhousie College and the Halifax Medical College from 1890 to 1895.

The well-earned honorary degree of doctor of laws was conferred upon him in 1892 by Dalhousie, and in 1905 he received the same honour from the University of St. Francis Xavier, Antigonish, N. S.

He was at the head of the department of education for nearly thirty-five years, or more than half the period our school system had been in existence. He finally retired from office on 31st July, 1926. Thereafter he devoted himself to study and research, while continuing to take his wonted keen interest in all intellectual work and every commendable cause in

Halifax. In Nov. 1928, a dinner in his honour was given by the Dalhousie Biology Club and a large number of his friends.

In May, 1929, while on his way to visit invalids at the hospital, he was caught in a drenching rain. This brought on a cold which developed into pneumonia. He passed away at his home, 163 Queen Street, Dartmouth, N. S., on his eighty-first birthday, 19th May. His last resting place is with his kin in the family lot at quiet Scotsburn, a few miles from his birthplace, and amidst the things of nature which he had loved so well.

In 1882 he had married Maude Augusta, only daughter of Dr. George Moir Johnstone of Pictou. Their children are a son, G. M. Johnstone MacKay, M.Sc., Schenectady, N. Y., and a daughter, Lois, wife of Dean Everett Fraser of the University of Minnesota, Minneapolis, U. S. A.

His activities were notably extensive and varied. He was a member or officer of many learned and other societies and clubs, and connected with the management of numerous institutions. With the Nova Scotian Institute of Science his association extended over the long period of fifty-four years; and he was an active worker and a most faithful attendant at all meetings, no matter what the weather, thus setting a good example to members far younger. He joined the society as an associate member on 11th Jan., 1875, and therefore was its senior active member; and became an ordinary member on 21st Oct., 1885. His first paper appeared in its *Transactions* in 1881. He was elected second vice-president in Oct., 1887, was corresponding secretary, 1890-92, and again in 1902-11, and president from Nov., 1899, to Nov., 1902. When not an official he served on the council. The *Proceedings and Transactions* were edited by him from about 1908 till his death.

Shortly before his death the Institute voted to present him with a suitably engraved piece of silver plate "as a token of deep respect and in recognition of his long and eminent service in the cause of science and education, ' and this was to have been given to him at a complimentary dinner on 11th May, 1929, but his last illness prevented the carrying out of this gathering in his honour.

He was also president of the Provincial Educational Association, 1874-76: in 1887 he organized the well-known Nova Scotian Summer School of Science, designed to prepare teachers for teaching the nature lessons in the prescribed course of study, and was its first president, 1887-88. He was also president of the Dominion Educational Association, and honorary vice-president of the World's Educational Congress, Chicago, 1892. He was a Fellow of the Geographical Association of the United States and a life member of the Royal Colonial Institute, a director of the Biological Board of Canada and the Nova Scotian member of the Geographic Board of Canada from its inception; president of the Victoria School of Art and Design, Halifax; president of the North British Society, Halifax, 1894; vice-president of the Nova Scotia Historical Society, 1896-1902; delegate to the Federal Conference of Education, London, Eng., 1907-12; vice-president of the Religious Education Association, 1908; member of the Simplified Spelling Board, 1909—"reformed spelling" being a subject in which he took much interest; president of the Botanical Club of Canada; president of the Canadian Club, Halifax, 1912-3; honorary president of the Canadian Defence League; a governor of Dalhousie University, a senator of the Halifax Presbyterian College, and a director of the Halifax Ladies' College.

He was a member of the executive of the Strathcona Trust for the encouragement of physical training and military drill in the schools of Canada, and was largely instrumental in introducing such training into the common and high schools of this province, in recognition of which he was made an honorary colonel in 1912.

Furthermore he associated himself with almost every other local organization for the advancement of intellectual and the betterment of moral and social conditions, and was present at most of the meetings. In fact I know of no one who gave his active support to so many worthy causes.

It is impossible to give here a list of his writings. The titles of thirty of his papers published before 1894, appear in the bibliography of the Royal Society of Canada, in its ***Pro-***

ceedings for that year. He wrote extensively on educational subjects, and prepared the "Sketch of Education in Nova Scotia" for the Encylopaedia of Canada, and articles for the British Special Educational Reports, and other publications. Besides these he prepared Annual Reports as superintendent of education.

His numerous scientific writings dating from 1881, were in the form of monographs, papers, or short articles. They are to be found in the old *Acadian Scientist* and its successor the *Canadian Science Monthly* of the 'eighties, the *Educational Review* ("Ferndale School", etc.), the *Canadian Record of Science*, Montreal, and the *Proceedings of the Royal Society of Canada*, although most of them appeared in our own *Transactions*. A large number of these are on botanical subjects, including the Diatomaceae and the ordinary Algae, while others are on freshwater sponges and on phenology, to the study of all of which he gave much time. Some are devoted to the popularization of nature study. He early began the formation of a herbarium of Nova Scotian plants, which was one of the seven collections upon which Dr. A. W. H. Lindsay in 1876 based his catalogue of our flora. This herbarium, I believe, was given by his family to Dalhousie University after his death.

As an editor he conducted the *Dalhousie Gazette*, 1870-3; was associated with A. J. Pineo in the editorship of the creditable *Acadian Scientist*, later the *Canadian Science Monthly*, Wolfville, 1883-5; and was Nova Scotian editor of the *Educational Review*, St. John, 1887-91, which journal he had assisted in founding in June of the first-mentioned year. Reference has been made to his editorial work for the N. S. Institute of Science.

As an educationist he gained a highly enviable reputation and has left a deep impress on our educational system. He was one of the ablest and most successful teachers we have ever had; and a large number of those whom he instructed and inspired, now occupy very distinguished positions in Canada and elsewhere. As superintendent of education he rapidly introduced many noteworthy improvements into our public school system, a summary of which is given in his annual report for 1891-2, page xviii, and he also brought into increasing prominence the study of nature and the teaching of elementary science, subjects which he believed to be of more practical value now than such time-honoured ones as the so-called dead languages.

His administration is thus referred to in the first report of his successor, Dr. Munro: "Dr. MacKay had administered the free schools during a period of momentous intellectual and social change. Merely to have piloted the educational bark so as to avoid shipwreck, shows skill; to have reconditioned it so as to make relative progress, merits high praise. That our educational system is essentially sound and can face with assurance whatever changes the future may hold, redounds to the credit of the man who has directed the policy of the education office for so many years. As he retires from active service, Dr. MacKay can be assured of the warm appreciation of his fellow citizens and of their sincere wishes for a long and tranquil eventide of well-earned repose."

I think it may be fairly said that MacKay was the ablest and most energetic superintendent of education who had theretofore occupied that highly important and onerous position.

As a scientist his attainments and fame are as great as those he acquired as an educationist, and his name was well known to specialists far beyond the Dominion. There was no branch of science in which he was not interested, but he devoted most of his time to biology, in certain departments of which he was a widely recognized authority. No one had a greater knowledge of the flora of this province.

In counsel his carefully considered and circumspect opinions were always valued; furthermore he had a happy adroitness in smoothing out points of difference and suggesting conciliatory solutions of difficulties. Once only did I hear him speak with unwonted warmth or perhaps anger, and that was when an educated man seemingly tried to demonstrate to a large audience that the world might be flat! He endeavoured at all times to encourage any worthy effort or well-meaning person. Despite a busy life, he was ever ready to give his precious time to anyone who sought his aid or advice, and particularly liked to help young or inexperienced naturalists. I never knew him to take a real recreative vacation, and he would laughingly say that such a thing as an educational conference gave him an enjoyable holiday.

When addressing an audience he spoke with great deliberation and with almost unduly marked pauses. In latter years he was troubled with deafness which to some extent prevented him from taking his former alert part in discussions. His handwriting was a characteristically careful one, and unusual in having all the u's distinguished by the short-vowel sign.

A personal touch may be pardoned in this brief sketch of a long and busy life. I first met Dr. MacKay when I was a lad of eighteen, and such even then was his fame throughout the province, that his presence seemed to inspire my boyish mind with a sort of reverential awe. After he came to Halifax I got to know him intimately and to fully realize the fine qualities of his mind and to esteem him for those of his heart. His death has deprived me of a firm and honored and confiding friend and a sympathetic companion and co-worker. It is a satisfaction to write these few words of deserved appreciation of such a man.

The accompanying portrait of Dr. MacKay is from a photograph taken in London, Eng., about 1910, and shows him in the prime of life. It has the added interest of being the one which he had himself selected at the request of the writer.

Halifax, N. S., 17th November, 1930.

TRANSACTIONS

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OBSERVATIONS ON THE SEASONAL DISAPPEARANCE OF CERTAIN MARINE ALGAE IN THE TIDE POOLS NEAR THE BIOLOGICAL STATION, ST. ANDREW'S, NEW BRUNSWICK.

By HUGH PHILIP BELL, M. SC., PH. D., Associate Professor of Botany, Dalhousie University, Halifax, N. S.

(Read 13 December 1926)

Along the Canadian Atlantic Coast the most conspicuous marine algae are such perennials as Fucus, Ascophyllum, etc., But there are also many annuals which appear and disappear regularly as the seasons come and go. These are different from land plants in that they are not confined to any one or two seasons, but provide a continuous succession of species from January to December. Each species, however, appears, reaches its maximum growth, and disappears at about the same time each year. With the great total length of our irregular coast and the rich growth of algae along the waterline, the amount of decaying or dead organic matter thus added to the water of the ocean may be very great. On the other hand if these plants are merely broken off in a firm healthy condition, and washed up on the shore to dry on the rocks, their contribution to the organic matter in the water may be very small. It is thus of importance to know just how such removal takes place and the condition of the tissues of the plant at the time of removal.

Interesting examples of these seasonal changes in the marine flora, came to my attention during the summer of 1925, while I was collecting in the vicinity of the Biological Station at St. Andrew's, New Brunswick. In the tide pools there, certain species of *Enteromorpha*, *Phyllitis*, *Scytosiphon* and *Halosaccion* were found in abundance and growing luxuriantly during the first part of June; but by the end of July it was difficult to locate any of them. As this time of maximum growth and decay coincided with the time one usually spends at the Biological Station, these forms were chosen as suitable material for a study of the conditions accompanying the seasonal disappearance of marine algae.

Observations on these forms were made during the summer of 1926. The study was confined to the plants growing in fourteen selected tide pools. These pools were all within easy reach of the St. Andrew's Biological Station. They were representative of every part of the tidal zone, and at the same time they were chosen so as to be as varied as possible in regard to other factors such as size, depth, exposure to the sun and waves, etc. The necessary records were made during the first two weeks of June. These included a rough map of each pool, measurements of depth, size etc., position in the tidal zone, and an inventory of the more conspicuous species of marine algae in each pool. These species included; *Enteromorpha prolifera*, (Fl. Dan.), J. G. Agardh; *Phyllitis fascia*, Kutz; *Scytosiphon lomentarius*, Ag.; *Fucus vesiculosus*, L.; *Ascophyllum nodosum*, Le Jolis; *Halosaccion ramentaceum*, Ag., Var. *gladiatum*, Eaton; and *Chondrus crispus*, (L.), Stack.

The pools were kept under constant observation till the first of September. The plants of *Fucus*, *Ascophyllum* and *Chondrus* were still present at the end of the period; but the plants of *Enteromorpha*, *Phyllitis*, *Scytosiphon* and *Halosaccion*, gradually disappeared, till by the middle of July they had almost gone, and by the middle of August there were none of them left in the pools. There are three common ways in which the removal or death of such plants is brought about, namely, (*a*) they may be broken off by the waves or ice and washed away, (*b*) they may be eaten by some marine animal and (*c*) the plants in their regular life cycle may decay and their decayed bodies be washed away in a more or less disintegrated condition. The ways in which the plants under observation became removed from these pools were different for each species, and will be given in detail below. There was, however, one common characteristic, they were all mutilated by the common periwinkle (*Littorina*), and when this animal had cut nearly through a frond, that frond usually broke off at the weakened spot. The observations made on each species were as follows:—

The *Enteromorpha* was growing epiphytically on *Scytosiphon*. Thus when the *Scytosiphon* broke away, the *Enteromorpha* was washed away too. At that time however the *Enteromorpha* appeared to be alive and growing normally.

Phyllitis, before fruiting took place, had a smooth tough surface. Sporulation took place during the last part of June and first part of July. At the start of this fruiting the cortical cells over the whole surface of the frond grew out to form what looked like short rows of spores at right angles to the surface. These spores were then given off from the distal ends of these rows or short filaments. After this took place, the texture of the frond was no longer firm, but became soft and easily broken; and what is more important this softening, disintegrating and consequent weakening took place throughout nearly the whole frond at once. Naturally in this weakened condition the plant did not long withstand either the feeding activities of the periwinkle or the action of the waves; and when it was thus washed away, it was in a more or less macerated condition.

Scytosiphon fruited during June. When fruiting was in progress, long sterile hairs grew out from the surface. These hairs floating in the water looked like a halo completely enveloping the frond. The spores were given off from the surface as in *Phyllitis*, except that there were in addition single celled paraphyses interspersed among the sporangia. When fruiting was over the long sterile hairs disappeared, the cells throughout the tissues of the frond became less compact and less resistant; but the paraphyses remained, so that the frond still possessed a fairly smooth surface of closely packed paraphyses.

Thus so far as I could observe, the disintegration of the tissues did not play such an important part in the removal of this plant as it did with either *Phyllitis* or *Halosaccion.* The important things with this plant were that the frond was very long and slender, and consequently easily broken; also the stipe connecting the frond with the hold-fast was very slender. As a result the periwinkle did not have to take a very big bite out of the side of either the frond or the stipe to cut either of them nearly through. So it is not surprizing that the fronds of this species broke off and floated away either whole or in very large pieces. Also if a frond happened to be left alone by the periwinkles it sometimes remained attached and unchanged in appearance for quite a while after spore-discharge was over. A few of these undisfigured fronds were still to be found in the pools until nearly the middle of August; and one or two of these still retained their maximum length. One could be reasonably sure regarding this last observation because the original tip of a frond of *Scytosiphon* is very easily recognized. Thus although disintegration of the tissue undoubtedly played some part in the weakening and consequent destruction of the fronds of this species, the most conspicuous factors were the feeding activities of the periwinkle and wave-action, with the result that the tissues were only partially macerated at the time of removal.

Halosaccion died from the tip of the frond towards the base or holdfast. This was coincident with the ripening of the tetraspores, and ripening started at the distal end of the frond. When these spores were ripe they were set free by the complete breaking down of the tissues surrounding them. In this way the tissues became washed away in a completely macerated condition. This process continuing with the advance of the season, made the frond gradually shorter and shorter till finally there was nothing left.

There were some facts observed which are of general interest. One was in regard to certain tide pools in which there was always a current of water, due to the fact that some pool at a higher level drained through each of these lower pools.

In all those where a current of water existed, the algae lasted longer and fruited later, than the forms growing in pools where no current existed. The pools under observation were sufficently numerous and varied to make possible a fairly complete comparison in regard to this point; and it appeared quite evident that the current was the controlling factor in lengthening the life of these plants and not position in the tidal zone, depth or size of the pool or exposure to light. Of course the current would influence the temperature and oxygen supply, but these points were not investigated.

The records as given above do not apply to these species throughout the range. For instance, long after *Phyllitis* had disappeared from the pools, there was a luzuriant growth of the same species just appearing on the break-water only a few yards from the shore where these pools were located. Also there were other species observed which had growing periods partially overlaping the period during which this study was conducted; that is, there were species which were disappearing during June and others just starting in July and August. From this it is evident that similar studies could be made in regard to a great many other species of marine algae, and that these studies should extend through the whole year.

From these records it is seen that *Enteromorpha prolifera, Phyllitis fascia, Scytosiphon lomentarius,* and *Halosaccion ramentaceum,* var. *gladiatum* in the course of their life cycle disappear from any one location; and that with these species this disappearance is brought about as follows:—wave-action operates in the removal of all four, and it is the chief factor with *Scytosiphon* and *Enteromorpha* growing epiphytically on *Scytosiphon.* The fronds of all four species are mutilated and eaten by the periwinkle. Decay or decomposition "in situ" takes place in the cases of *Phyllitis* and *Halosaccion,* although *Phyllitis* is sometimes washed away in fairly large decaying pieces. This decay or decomposition "in situ" is not so marked with either *Enteromorpha* or *Scytosiphon.*

The facilities provided by the Biological Board of Canada at the St. Andrew's Station, made these studies possible.

The Effect of Environmental Factors on the Development and Growth of Littorina littorea. — By Frederick Ronald Hayes, B. Sc., Assistant in Histology and Embryology, Dalhousie University, Halifax, N. S.

(Read 13 December 1926)

While engaged in a general investigation of the biology of *Littorina littorea*, the common periwinkle, at the Atlantic Biological Station, St. Andrews, N. B., during the summer of 1925, the remarkable paucity of information regarding the factors influencing the development and growth of this species led to a series of experiments designed to give some information about this subject. The effect on development of decreasing the salinity of the water, an effect that would frequently act in the natural life of the species, was worked out in as quantitative terms as equipment and time would permit. Experiments were also performed and an analysis attempted, of the relative importance to growth of the common environmental factors, light, temperature and moisture.

Reproduction and Embryological Experiments.

Very little is known in detail of the breeding habits of *Littorina*. An unidentified Gastropod egg found on the Nova Scotia coast is described by Wright (1907). Tattersall (1920), rightly identifies the egg as that of *L. littorea L.* Caullery and Pelseneer (1911) have identified by a process of elimination, as belonging to *L. littorea*, an egg found in abundance at Wimereux, France. They were not, however, able to confirm their observations by inducing the adults to breed in the laboratory. I have found eggs in their characteristic cases in large numbers in plankton tows taken near the shore at St. Andrews, and, in markedly smaller numbers, in plankton tows taken off Navy Island, farther from the shore. Very small specimens of fully developed periwinkles have also been found in plankton tows, suggesting the possibility that development might proceed to the adult body form before the individual assumed its littoral existance.

The date of commencement of the breeding season has not been determined but it is undoubtedly very early, since small fully developed specimens could be found on the rocks at low tide level early in June when the first observations were made. Individuals have been induced to copulate as late as July 24, although the number copulating was notably smaller than earlier in the season (July 7th).

Tattersall states: "The sexes in *L. littorea* are separate, and, in the breeding season, the males are readily distinguished from the females by the possession of a long, rather stout penis on the right side of the body." (The penis is an erectile organ and is situated just behind the right tentacle). "The penis appears to exhibit seasonal variations in size and only attains its full development when the testis is completely ripe. At the close of the breeding season the penis becomes reduced in size externally, and against the darkly pigmented epidermis of the body, is almost invisible.

The separation of the sexes becomes difficult except the animals are removed from their shells. When the next breeding season is approaching and the generative cells are once more active, the penis again increases in size, and, keeping pace with the maturation of the sperm cells, reaches full size with the appearance in the vas deferens of ripe spermatozoa. The testis is a diffuse organ ramifying through the hepatic coil, and giving to it a pale yellow-brown color in the breeding season. The ovary is likewise diffuse but pink in color."

L. littorea was the only species with which any embryological experiments were performed. To induce copulation, in order to obtain eggs, individuals were freshly brought in and a large number were placed in a shallow granite pan which was filled to a depth of several centimetres with fresh sea water. The animals were then watched till a pair were observed copulating, when they were removed, being disturbed as little as possible, to a quart jar filled with sea water. When copulation was over, the female was placed in a four ounce bottle filled with carefully filtered sea water, and a piece of finest bolting silk tied over the mouth of the bottle, which was then suspended from the end of the wharf over night. Next morning the bottle was taken in and the eggs, usually over 200, removed to a suitable container. The eggs rested on the bottom of the bottle in their egg cases, and could be handled with a fine pipette.

Some notes were made regarding the mechanism of copulation. It was observed that during copulation the female invariably is the individual attached to the substratum, while the male clings to the shell of the female in such a way that the erected penis may be inserted under the mantle of the female immediately above the right tentacle. The female does not walk about during copulation but remains inactive except for the extended tentacles, which move about through the water. Some pairs of *L. littorea* were timed to see how long copulation lasted. One pair of animals was observed together and nine minutes later were seen to be copulating. Three minutes later they had separated. In another case copulation lasted for a minute and a half; while another copulation observed lasted two minutes.

When the eggs were brought in, about fifteen hours after copulation, they were for the most part, in the one cell stage, a few being advanced to the two or four cell stage. The eggs were encased, one or more, in the typical egg case which looks like a Chinese hat, with the eggs in the hollow crown. As many as seven eggs have been seen in a single case, though three is the number most commonly found. The usual sizes of the characteristic structures are about as follows:

Diameter of the entire capsule	0.85 to 0.65 mm.
Width of the brim of the capsule	0.16 to 0.13 mm.
Diameter of the egg membrane	0.18 to 0.16 mm.
Diameter of the egg	0.15 to 0.12 mm.

The eggs brought in were transferred to four ounce bottles containing water of varying salinities,about twenty eggs being placed in a bottle. The salinity was reduced by adding aerated distilled water to fresh filtered sea water. The bottles were corked and hung off the breakwater, thus being restored to their natural temperature conditions. Controls, using both cork stoppers and bolting silk over the mouth of the bottles, were run, using normal sea water. The salinities used were 0, 5, 10, 15, 20, 25, 30 gms. per mille, and normal controls. Five bottles of each of the low salinities were used and a bottle was taken in periodically and the eggs examined.

In salinities of 0 and 5, no development took place. Under these conditions eggs remained at precisely the same stage as when placed there, for a few days and then died, and great enlargement in size and disintegration ensued.

No development past early segmentation stages in the capsule could be found under salinity conditions of 10. Segmentation was unequal, and while the eggs appeared capable of living indefinitely, they never developed very far.

In the water of a salinity of 15, development proceeded slowly but not normally. The early trocophore stage lacked the usual ring of circumoral cilia and was very irregularly shaped. The eggs, however, were clearly able to live and develop at this salinity although abnormally. It took ten days for a trocophore to appear. No veliger larvae were found although they might have appeared had the eggs been permitted to develop for a sufficiently long time.

In salinity of 20 or over, development appeared to progress normally, although the lowered salinity slowed the rate of development down somewhat. Segmentation was completed during the first day of development in normal sea water. By the third day the circumoral ring of cilia was complete and the embryo began to rotate in its membrane. The embro as a young veliger, broke from the capsule at the sixth day and swam about freely. These veliger larvae are so minute that they are rather difficult to find in a bottle of water. A dark background proved to be of considerable help in the study of this stage. The early veliger resembled very closely Wright's figure. An examination of the empty capsules, after the embryos had broken out, confirmed the observations of Caullery and Pelseneer that the larvae breaks through the flat side of the capsule when escaping

No success rewarded efforts made to carry development to the adult stage. The reason is doubtless that the problem of how to feed the embryos was unsolved. Reliance on the plankton naturally in the water, for service as food, was impossible since unstrained sea water proved most detrimental to development, the diatoms and protozoa multiplying so rapidly that the water soon became foul.

EXPERIMENTS TO DETERMINE RATE OF GROWTH.

In the growth experiments small specimens of *L. littorea* were used, ranging in size from 2.4 mm. to 3.2 mm., although very few of the individuals used were larger than 3.0 mm. A large number of these tiny animals was collected from the crannies of a rocky ledge 1.5 metres above low tide level, near the Station. These were measured in the laboratory and divided into three groups. The single measurement recorded represents the greatest length from tip of spire to lip, as observed through a low power objective with a calibrated ocular micrometer. Each individual was placed on a slide and held with a pair of fine forceps in such a way that the greatest length could be determined. Fifty individuals were put in each of the three groups and each group was placed in a one-pint jar along with a supply of *Enteromorpha linza*, amply sufficient to provide food for a longer period than the test was expected to last. *Enteromorpha linza* was the alga selected chiefly because examinations of stomach contents had shown this form to be one very commonly eaten by *L. littorea*, and also because it appears to be a hardy form, capable of withstanding a considerable intertidal exposure. The one-pint jars used were fitted in a sort of harness made of pieces of net so that they could be suspended horizontally from a projection on the side of the Station wharf. The mouths of the jars were covered with a single layer of 1 mm.

bolting silk; so that when the jars were thus placed, as the tide rose and fell, each one would fill and empty and there would be a condition established similar to that encountered by an individual living in a sheltered cranny. The number of individuals placed in a single jar was known to be too few for there to be any danger of over-crowding, since 75 adu t *L. littorea* had remained in good physical condition after an immersion of over seven weeks in a quart jar.

The experiments were carried out in August and September, and observations indicated that the place selected on the pier from which to suspend the jars, received about five hours of sunlight each bright day. Thus when tides and sun synchronized, a jar exposed for five hours or more between high tides could receive a maximum of five hours sunlight.

A cord was hung, weighted at the lower end, which rested on the substratum, from the south side of the pier. The three jars were attached to this cord at various levels.

The following table gives an idea of the conditions to which the animals were subjected. It will be noted that the "low tide" group was placed at approximately its normal level, while the "high tide" group was at approximately the highest level at which *L. littorea* is found in the littoral zone, except in tide pools.

	Size of individuals used in milimetres.	Height above low tide-level in metres.	Average exposure of jar between tides in hours.
Low Tide Jar......	2.4 to 2.6	2	3.5
Mid. Tide Jar......	2.6 to 2.8	4	7.0
High Tide Jar.....	2.8 to 3.0	6	10.0

The jars were first immersed on August 3rd. The periwinkles were examined and again measured on August 12th.

At this time the *Enteromorpha linza* remaining was, for the most part in a healthy condition, although some small pieces were dead. After measurement a fresh supply of the alga was used and the jars cleaned and replaced over the wharf. The jars were taken up again on Sept. 16th and the animals again measured. An abundant supply of *Enteromorpha* still remained, and appeared to be alive. Some individuals examined at the September 16th reading were found to be dead and exhibiting only a very slight increase in size. It was assumed that these had died early in the experiment and they were therefore discarded and not considered in calculating the average size of the group.

The results of the measurements given are for the average of each group of fifty in a jar. They are as follows:—

(Average sizes in millimetres).

	Aug. 3	Aug. 12	Gain. 9 days	Sept. 16	Gain 44 days.
Low Tide	2.59	2.82	0.23	4.73	2.14
Mid. Tide	2.74	2.87	0.13	4.72	1.98
High Tide	2.90	2.92	0.02	3.20	0.30

From the results of these observations, conducted with a sufficiently large number of individuals to render an average reasonably accurate, it can be seen clearly that immersion is a more important factor in growth than is warmth and sunlight gained during intertidal exposure. The only other possible interpretation of the facts is that smaller individuals grow more rapidly, and this is rendered unreasonable by an observation of the size differences.

Some preliminary experiments conducted with *L. littorea* by Dr. A. B. Klugh indicate that they grow extremely rapidly at high temperatures. He kept some individuals in small vials on a window ledge exposed to full sunlight and found very rapid growth, but the animals were only able to survive the high temperature for a few days.

SUMMARY AND CONCLUSIONS.

Littorina littorea exhibits a generalized type of Gastropod development, is oviparous and may make several depositions of eggs after one copulation. The eggs are enclosed, several together, in a very characteristic capsule. Under normal conditions the developing embryo passes through the trocophore stage inside the capsule, breaking forth as an early veliger about the sixth day after fertilization. Eggs or embryos are incapable of existing in water of salinity under 10 gm. per liter. In salinities of 10 to 15 an egg can remain alive for some time, but cannot develop. Development can proceed if the salinity is 15 or over, but the salinity must be 20 or over for normal development. Salinities ranging from normal down to 20 retard development.

Experiments conducted with a view to determining the rate of growth showed that a small individual can double its length in less than two months under favorable conditions. Animals at low tide level grow much more rapidly than those at higher levels, showing that immersion is a more important factor in growth than is warmth and sunlight gained during exposure.

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AN INSTALLATION FOR THE PREPARATION OF RADIUM EMANATION FOR THERAPEUTIC USE.—BY GEORGE HUGH HENDERSON, PH. D., King's College, Halifax, N. S.

(Read 15 November 1926)

Abstract: A description is given of a method used for the purification and tubing of radium emanation, which gives high purification although simplified considerably by the avoidance of drying agents.

Radium was first used for therapeutic purposes in the form of a salt sealed permanently into small glass tubes. This method is gradually being abandoned in favour of the use of radium emanation, the radium being kept in solution in a safe place, while the gaseous emanation is pumped off regularly, freed from impurities and sealed into glass tubes.

The advantages of the latter method over the former are threefold. The costly radium can be kept in a safe, while the emanation tubes if lost or destroyed, may be replaced at the cost of only a short delay. The emanation method possesses great flexibility as the emanation can be subdivided in any desired way and distributed where needed. Finally the emanation can be concentrated more than a salt of radium, permitting the use of smaller tubes—a very decided advantage.

The preparation of emanation tubes is not very easy. The main difficulty arises in the purification of the emanation, which necessitates a complicated purification process, a costly pumping system, experimental skill and much experience.[1] The emanation as first collected is mixed with large quantities of hydrogen and oxygen from the water of the solution, as well as carbon dioxide from tap grease. The mixed gases collected with one millicurie of emanation amount to at least 200 cubic mm, while modern usage demands a concentration of not less than 25 millicuries in a cubic mm. Thus the impurities must be reduced at least 5000 fold.

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[1] Hahn, Ber. Deut. Chem. Ges. 59. p. 284. 1926.

It has usually been stated that at least one gram of radium is necessary to justify the erection of an emanation plant, and accordingly the use of radium in this way has been restricted to a few large centres of population. Recently the Victoria General Hospital, Halifax, N.S., purchased 200 mgs. of radium, and the writer undertook to develop an emanation plant suitable for handling this relatively small quantity. Obviously, the first considerations must be low first cost and simplicity of operation. A description of the method evolved forms the subject of this paper.

METHOD.

Many descriptions of purification methods have been given.[2] In general the hydrogen and oxygen are united by sparking the mixture and carbon dioxide removed by potassium hydroxide. An excess of hydrogen always remains after sparking, and several methods have been used to remove it. (1) In a purely physical method, the emanation is condensed by liquid air and the hydrogen pumped off. (2) The hydrogen may be removed by hot copper oxide. (3) An excess of pure oxygen may be added before sparking, and the excess later removed by phosphorus.

The first method permits of high concentration of the emanation, but requires a regular supply of liquid air, which is generally inconvenient and in many localities impossible. Experience with chemical methods indicated that sufficient purification could be obtained only by the second method, and then only if the copper oxide were raised to a bright red heat. This method seems first to have been described by Duane and later elaborately developed by Failla. The apparatus to be described is simpler than that of Failla. The emanation after purification passes directly into the final capillary tube without further pumping or handling, and the use of phosphorus pentoxide has been avoided.

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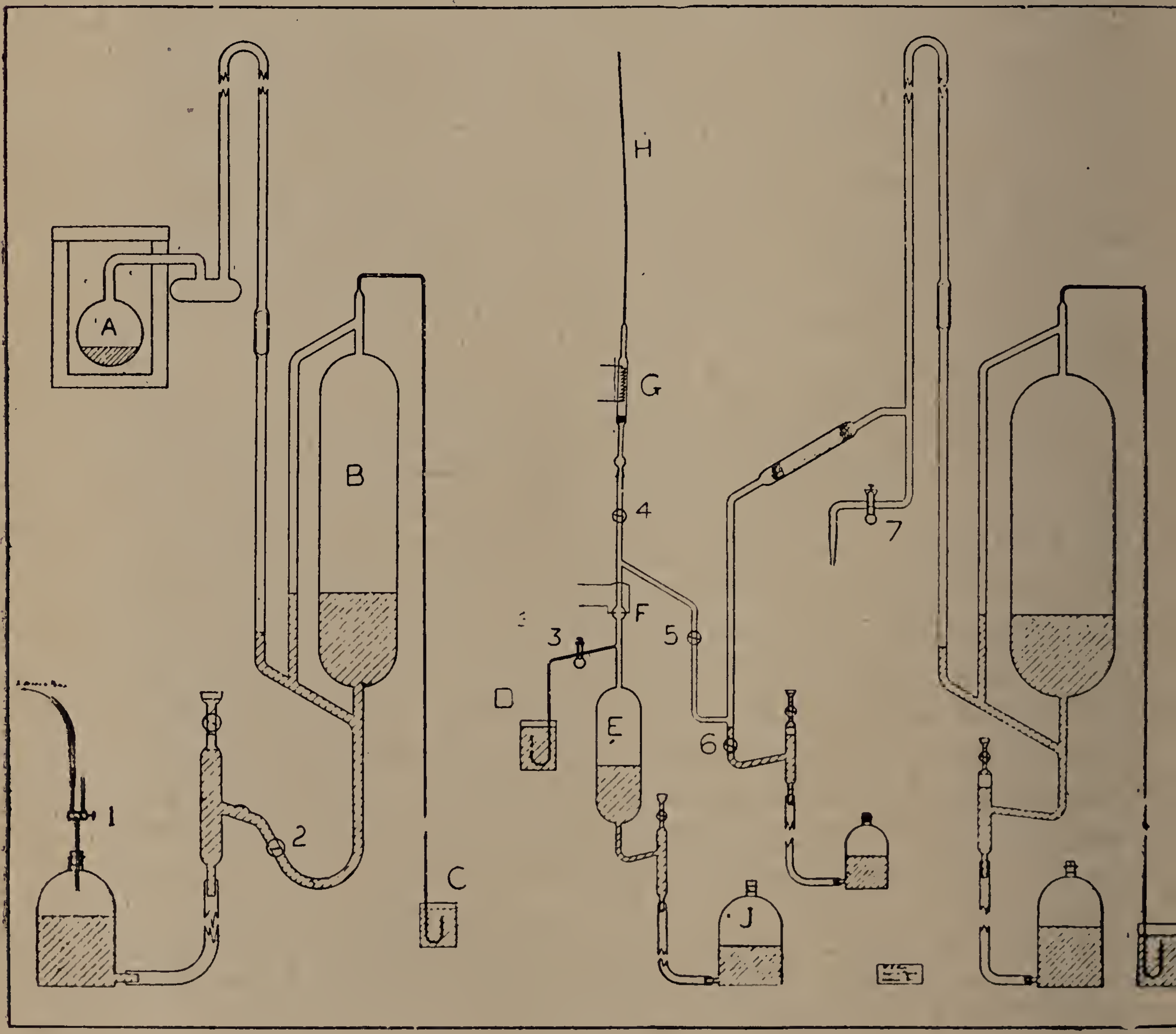
[2] Hess. Phil Mag. 47. p. 713 1. 24. q. v. for further reference. Alton, A Clinical Index of Radium Therapy. The Radium Institute, London 1925. Viol, Radium XIV. Oct. 1919.

The radium bromide is contained in the flask A (See Fig.) disolved in water to which a little hydrochloric acid has been added. The emanation is pumped from the solution by the Toepler pump B, and collected in a small tube over mercury in the trough C.

The purification apparatus EFGH has been previously evacuated thoroughly through the pumping system shown on the right of the line FH., after which taps 4 and 5 are closed.

The emanation is then transferred in the small tube referred to above, to the trough D, and allowed to enter E. A spark is passed in the mixture between the platinum electrodes F,



uniting the hydrogen and oxygen explosively. Tap 3 is opened and the gas pushed up into G for final purification by means of the merury cistern below. G is provided with a spiral of oxidized copper, which may be heated electrically, and with some potassium hydroxide fused to the glass just below the coil. After 10 minutes exposure to the wire at a bright red, the purification is complete. The heating current is cut off and the emanation compressed into the capillary tube H, which is sealed off with a small gas flame and subdivided as desired.

The essential feature of this method is that the purification takes place progressively along the line EFG and that the emanation is pushed directly into the capillary F without further pumping. This is possible since there is no phosphorus pentoxide in the purification line as a drying agent. Removal of water vapour has been found unnecessary, the vapour apparently condensing on the walls as the emanation is compressed.

DETAILS.

Some details may be of interest. The flask A is surrounded by a Pyrex beaker and an outer porcelain dish in case of breakage. The whole is enclosed in a lead safe with walls one and one half inches thick. Lead screens about an inch thick also cover the traps between A and B. In case of accident the mercury is prevented from rushing into A by (1) a glass float valve, (2) by making the tube connecting B to A rise to more than barometric height above the top of B. (3) by an emergency trap near A.

The pump B is semi-automatic in action. Its mercury cistern may be connected by the three-way tap, either to the atmosphere or to a vacuum pump (Hyvac oil pump). Thus the mercury in B may be moved up and down without moving the cistern. The cistern is connected to the pump B by rubber tubing and must be raised to push the larger quantities of gas over the top of B into C. Tap 2 is closed except when pumping off. It is placed in such a position that it can readily be cleaned without admitting air into B.

All the purification apparatus has been erected on heavy galvanized wire netting. This has been found a very simple and satisfactory mounting which provides easy access for glass blowing and does not warp.

The coil G of No. 30 copper wire is heated a bright red by a current of 10 amperes at 8 volts. It is coated with oxide by exposing it to the air for about one minute at a dull red. With care, such a coil may be made to last for a number of purifications. G is connected to tap 4 by a ground glass joint, facilitating change of capillary H.

The purification apparatus is roughly evacuated through tap 7 and a phosphorus pentoxide tube, by the same vacuum pump which actuates the pump B. After 7 is closed, three or four strokes of the Toepler pump shown on the right completes the evacuation. Connection between this pump and the purification line EFGH is cut off by opening tap 6, raising the attached mercury cistern until mercury flows into E, then closing 5 and 6.

The apparatus could be further simplified by connecting the emanation pump directly to the purification line, joining the top of B to tap 3. This has not been done in the present instance, partly because separation ensures greater protection to the operator. The pumping system on the right of the diagram might be replaced by a single mercury vapour pump, if as is usually the case, there is no need for saving the pumped off gas.

PERFORMANCE.

The capillary tube H is used in two sizes producing two kinds of emanation tubes usually called "tubes" and "seeds". The emanation is sealed off at a pressure about two-thirds of atmospheric.

"Seeds" are about .7 mm. external and .25mm. internal diameter and 4 mm. long. They can easily be made to contain 5 millicuries, though a strength of 2 mc. is preferable.

"Tubes" are about 1.1 mm. and .5 mm. internal and external diameters respectively and 15 mm. long. Usually 25 millicuries is sufficient, though they may be made to contain 75mc.

The apparatus has been found to produce emanation tubes averaging in strength about 94% of the theoretical yield. The installation has been in operation for over six months and has proved simple and reliable in operation.

In conclusion I wish to thank Dr. D. McIntosh for generous help and Mr. W. G. Moran, B. Sc. for the drawing.

DIGESTION IN FUNDULUS HETEROCLITUS L. (ABSTRACT).—BY PROFESSOR BORIS P. BABKIN, M. D., D. SC., Department of Physiology, Dalhousie University, Halifax, N. S.

(Read 13 December 1926)

Fundulus heteroclitus L. is deprived of the stomach. A short oesophagus is connected directly with the intestine into which are flowing bile and pancreatic juice. The extract of the intestinal mucous membrane contains: amylase, lipase, enterokinase, and erepsin. The bile from the gall bladder contains: amylase, protrypsin, and prosteapsin. The last two enzymes are activated by the extract of the intestinal mucous membrane. How the pancreatic enzymes could be admitted to the bladder bile was not investigated.

THE MEASUREMENT OF RENAL SECRETION (DEMONSTRATION).—By OWEN S. GIBBS, M. B., CH. B., Pharmacology Dept., Dalhousie University, Halifax, N. S.

(Presented 13 December 1926)

In the course of a series of experiments on the kidney function of the fowl occasion arose to record graphically certain changes, namely the amount of urine secreted, and the secretion pressure. Owing to varying nature of the fowl's urine the available drop recorders proved quite unsatisfactory for secretion records, in consequence a special method was adopted. The urine is allowed to flow into a fine rubber condom which is fastened in a glass cylinder, and surrounded by salt solution. As the urine enters the condom it displaces an equal amount of fluid from the cylinder. The fluid being constant in character readily allows of measurement, which in these experiments was accomplished by means of a simple type of electrolytic recorder[1]. Secretion pressure is measured graphically by means of a piston recorder attached to a manometric tube, to which is arranged a special method of filling, this being for the purpose of recording any inflow that may take place.

The purpose of these experiments is an attempt to elucidate the cause of secretion pressure. This may be due to vital secretion or filtration, these being positive, and reabsorbtion a negative factor, or any possible combination of these factors.

Ureteral movements, which are recorded very well by the above apparatus, are apt to complicate the tracing and in consequence some attention has been paid to the factors which control these. These experiments are as yet not completed, but so far only drugs acting on the sympathetic system appear to act definitely on the ureters, and even these somewhat inconstantly. Asphyxial changes cause a definite increase of movement, followed rapidly by a cessation.

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[1] The details of this apparatus are to be published in the Jour. of Lab. & Clin. Med.

Changes in secretion pressure have been brought about by means of blood-pressure alteration, either due to peripherally acting drugs, cardiac inhibition, or asphyxial changes, and further experiments of this type are in progress. Generally speaking a drop of blood-pressure, if of sufficient duration, causes a decrease of secretion pressure, the contrary however does not hold. The interpretation of the results of the above experiments are at present impossible since no data is available regarding the actual blood-flow through the kidney. This very difficult problem is now being considered.

COMPOUNDS OF THE HALOGENS WITH EACH OTHER, AND WITH THE HALOGEN HYDRIDES.

—By KEITH HUESTIS BUTLER, M. A. AND DOUGLAS MCINTOSH, M. A., D. SC., Dept. of Chemistry, Dalhousie University, Halifax, N. S.

(Read 13 December 1926)

During the study of the rise in boiling points of substances dissolved in liquefied chlorine, the ebuilloscopic constant for bromine was found to be much higher than for other substances. This may be due to dissociation of the bromine molecule, although the solution exhibited no electrical conduction, or to deviations from Raoult's law, due to combinations between solvent and solute. On this account, and in an effort to complete the studies made of the two component systems of the halogens and halogen hydrides, we have examined the freezing-point curve of the system cholorine-bromine. The results are given in this paper and show that combination does not take place.

Of the many investigations undertaken on this subject, the following may be briefly mentioned; Chlorine and hydrogen chloride; no compounds (Maass and McIntosh). Bromine and hydrogen bromine; no combination (Buechner and Karsten). Iodine and hydrogen iodine; no compounds (Beckmann and Wentig and Maass and McIntosh). Chlorine and iodine; two compounds, ICl and ICl^3 (Stortenbeker). Bromine and iodine; no compounds[1]. Bromine and chlorine; no compounds (Butler and McIntosh). It should be possible by the aid of the electron theory of valence to fix the constitutions of these few compounds, and to obtain a better knowledge of the interaction of halogens and organic substances.

In view of the few combinations formed it is not without interest that the ions of the halogens seem particularly active in forming compounds with the halogens. Potassium iodide dissolved in water apparently unites with iodine to form KII^2, and probably other compounds act in a similar way. (Jakowkin).

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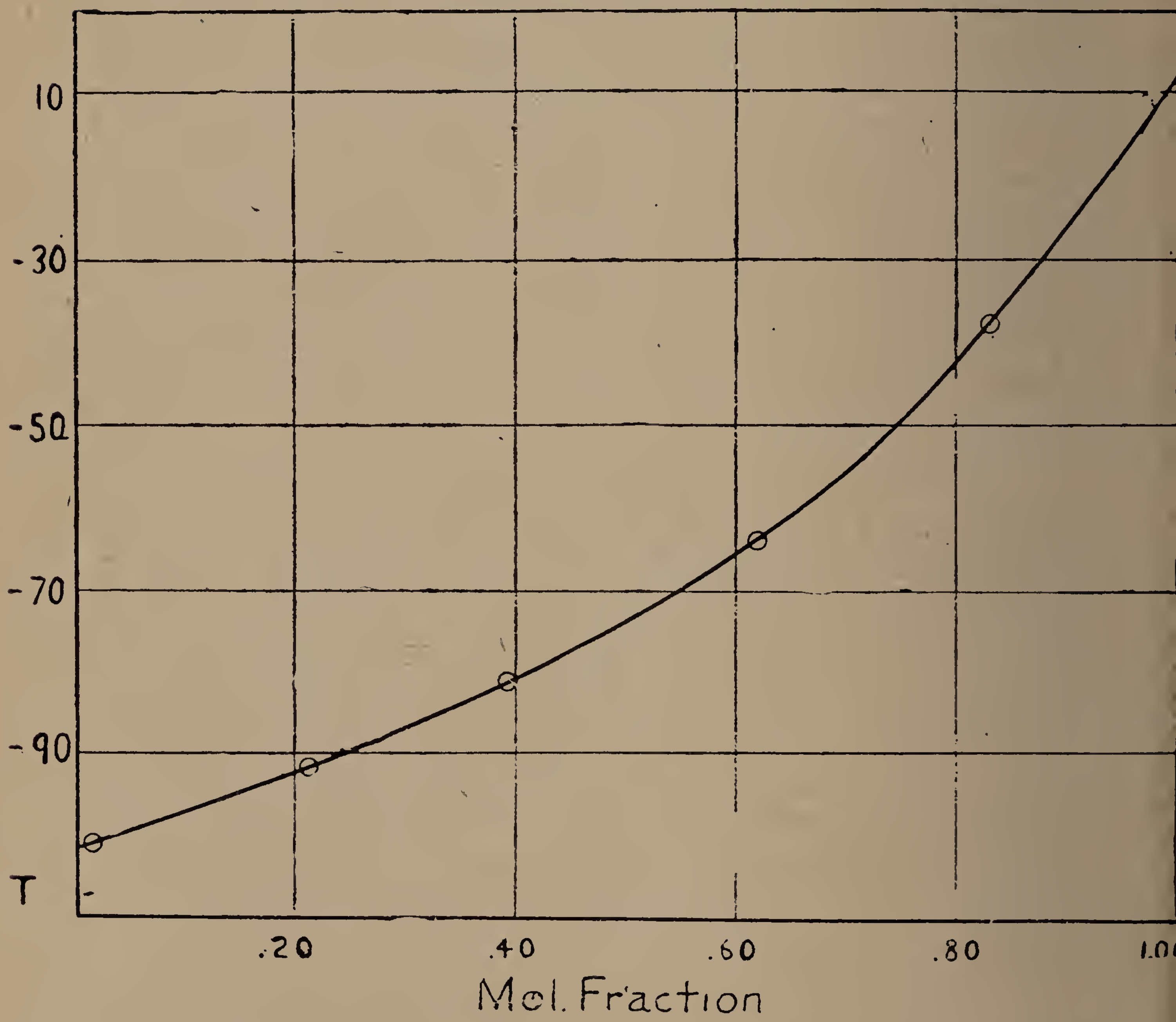
[1] Recent work by Mueller, Bodenstein and Schmidt indicates the existence of compounds of these two halogens at high temperature.

Experimental. The apparatus consisted of a vacuum jacketed freezing-point tube with a stirrer and platinum resistence thermometer, and a Leeds and Northrup potentiometer. Temperatures could be determined to one-tenth of a degree.



The solutions were cooled with a mixture of solid carbon dioxide and ether, so arranged that it could be evaporated under reduced pressure, and temperatures as low as —105°C obtained.

The results are given in the table and shown on the curve. Apparently there is no maximum point, the freezing temperature changing gradually from that of bromine to chlorine, indicating that no compounds are formed. This conclusion is in agreement with the views of Berthelot, LeBeau and Karsen, but is opposed to the work of Thomas and Depuis.

Finally, it is difficult to explain the combination of iodine with three atoms of chlorine, and the iodine ion with two atoms of iodine by the electron theory.

Mol. Fraction, Bromine.	Freezing Temperature.	Mol. Fraction Bromine.	Freezing Temperature.
0.000	–101.5	0.508	– 72.7
0.012	–101.0	0.554	– 69.2
0.025	–101.3	0.566	– 67.3
0.049	–101.0	0.614	– 63.9
0.102	– 98.2	0.621	– 62.5
0.135	– 97.0	0.657	– 59.0
0.172	– 94.8	0.673	– 57.6
0.216	– 92.2	0.704	– 53.7
0.262	– 90.2	0.705	– 53.6
0.305	– 86.7	0.733	– 51.4
0.332	– 86.0	0.745	– 49.3
0.363	– 83.3	0.763	– 46.3
0.384	– 82.3	0.775	– 45.6
0.394	– 81.3	0.798	– 40.5
0.399	– 81.0	0.820	– 36.6
0.436	– 79.4	0.852	– 30.8
0.463	– 77.0	0.931	– 22.8
0.477	– 74.4	0.944	– 21.1
0.486	– 74.7	0.983	– 12.4
0.504	– 73.4	1.000	– 8.1

ACETONE BODIES IN URINE ON CARBOHYDRATE AND FAT DIETS.—BY N. B. DREYER, B. A. (CAPE ET OXON), M. A. (OXON), M. R. C. S. (ENG.), Assistant Professor in Physiology, University of Dalhousie, Halifax, N. S.

(Presented 10 January 1927)

Acetone bodies include acetone, aceto-acetic acid and B-hydroxy-butyric acid. The last named is fairly stable and does not break up unless treated with strong oxiding agents. Aceto-acetic acid on the other hand, is easily split up, giving off acetone. The results described below refer to acetone and aceto-actic acid only.

Acetone determinations were carried out by the Scott Wilson method(1).

Summary of Results:

On mixed diets of carbohydrate fat and protein, acetone bodies showed marked variations from day to day.

On carbohydrate diets carried out for a period of eleven days, where fat was cut down to a minimum, acetone bodies gradually decreased, until finally only traces were detected. The ordinary qualitative nitroprusside reaction was negative, but quantitative estimations revealed presence of acetone in concentration of 0.0058 mgm. per 100 cc. urine. On the twelfth day the diet was changed to one rich in fat, and carbohydrate was reduced to a minimum. Acetone bodies increased, but at the end of the first twenty-four hours, the quantity had only increased ten-fold. The large quantities of glycogen in the body, stored while on carbohydrate diet, presumably acted as a catalyst in oxidising the fatty acids. On the fourth day of feeding fat, the acetone bodies had increased several hundred fold. On feeding carbohydrate with fat the amount was cut down considerably.

The effect of protein was not tested.

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[1] Scott Wilson. Journal of Philosophy, Vol. XLII, 1911

THE MEASUREMENT OF THE RENAL BLOOD-FLOW IN THE FOWL.—BY OWEN S. GIBBS, Pharmacology Dept., Dalhousie University, Halifax, N. S.

(Read 14 February 1927)

The method adopted consists of diverting the renal venous out-flow into the corresponding femoral vein. This is accomplished by compressing the superior, and inferior, veins of the kidney, thus leaving but one outlet for the renal blood. The blood issuing from the canularized femoral vein is passed through a recording instrument and re-enters the circulation by means of the jugular vein.

The recording instrument is essentially a double acting engine, with a separate reversing valve, both being of somewhat special design, partly in order to avoid metallic contact with the blood, and partly for ease in construction.

The recorder itself consists of two small glass funnels, the wide ends covered with thin rubber and clamped opposite each other. Between them is a light hollow drum which acts as a piston. As fluid enters one funnel the rubber expands and pushes the piston into the opposing funnel, thus emptying it. The piston movement is controlled by the contact which activates the valve that reverses the flow to the recorder. The contact is adjustable, but the instrument is set for a 2 cc. stroke.

At present this work is in an early stage, and still presents some difficulties, the greatest being that of clamping the renal veins without damaging the kidney. This is especially difficult since the blood is rendered abnormally incoagulable by means of heparin, and thus even a slight injury leads to marked bleeding.

A few records have however already been obtained and these present some interesting features. Under the conditions of the experiment great variations of the flow have been obtained, varying from 400 cc to over 3000 cc per hour for one kidney. The explanation of these changes is at present under consideration.

Summary.—A method is described whereby continuous records may be made of the blood-flow through the fowl's kidney.

ATTEMPTS TO SEPARATE THE ISOTOPES OF MERCURY BY CHEMICAL MEANS.—PROF. HAROLD S. KING, Dalhousie University, Halifax, N. S.

(Read 14 February 1927)

Introduction.— Isotopes have been defined as substances chemically identical yet differing in atomic mass. For instance, chlorine is composed of two isotopic forms, one with atomic mass 35 and the other with atomic mass 37, but is completely free from any substance with atomic mass 35.46, the atomic weight of ordinary chlorine. The atomic weight of an element, therefore, is the statistical average of the atomic masses of its atoms. Chlorine, wherever found, in whatsoever kind of combination, nevertheless has the same atomic weight.[1]

It follows that the mixture of chlorine isotopes is remarkably uniform throughout nature. Iron and nickel, two other elements isotopically complex, from both meteoric and terrestrial sources, have invariant atomic weights within the limits of experimental accuracy.[2] Brönsted and Hevesy[3] have compared a large number of samples of mercury from a wide range of mineralogical, geological and geographical sources, and found no appreciable difference in the proportions in which its six isotopes are mixed. There is no evidence that any of the many chemical reactions, in which these elements must have taken part throughout geological eras, has produced a detectable change in the isotopic ratio.

Though isotopes have been separated by certain physical means that take advantage of their differences in mass, no laboratory method based on chemical fractionation has been successful even to the slightest degree. Much of the early work on the comparative chemistry of isotopes was done without a knowledge of the extreme similarity of the structures of isotopic atoms. According to modern theories of atomic structure, isotopes differ only in respect to their nuclei, the number of electrons about these nuclei being the same. It has been shown in various ways that the outermost or valence electrons are chiefly responsible for the chemical properties of the atom as well as for most of the lines in the visible spectrum. The similarity of spectral lines from isotopic atoms, therefore, indicates that the orbits of these electrons must be very nearly identical.

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[1] E. Gleditsch and B. Samdahl, Compt. rend. **174**, 746 (1922); M. Dorenfeldt, J. Am. Chem. Soc. **45**, 1577 (1923); A. W. C. Menzies, Nature **116**, 643 (1925); W. D. Harkins and S. B. Stone, J. Am. Chem. Soc. **48**, 938 (1926).

[2] G. P. Baxter and T. Thorwaldson, J. Am. Chem. Soc. **33**, 337 (1911); G. P. Baxter and L. W. Parsons, Ibid. **43**, 507 (1921); G. P. Baxter and F. A. Hilton, Ibid. **45**, 694 (1923).

[3] J. N. Brönsted and G. Hevesy, Nature **109**, 780 (1922).

However, Aronberg,[1] in a comparison of the wave lengths of the line 4058Å from ordinary lead (at. wt. 207.2) and lead from Australian carnotite (at. wt. 206.3), found the latter to be 0.0044Å greater. Merton and Perretta[2] have confirmed and extended this discovery. Thus the mass of the nucleus has an effect, in this case of the order of one part per million, on the wave length of radiation from an electron. Therefore the vibrations of the valence electrons can not be identical in isotopic atoms, though the difference may be too small to change the chemical properties appreciably.

Loomis and Kratzer,[3] independently, pointed out that much greater differences occur in the infra-red absorption bands of isotopic molecules, such as HCl^{35} and HCl^{37}, where the two vibrating masses, H and Cl, are more nearly equal in mass. For instance, each line of the "first harmonic" band at 1.76μ has a satellite separated by an average interval of 14Å, the main lines being due to HCl^{35} and the satellites to HCl^{37}. Thus the vibrations within a molecule, made up of two or more atoms, are much more affected by isotopic differences than are those of an electron in a single atom.

Lindemann[4] has discussed this same problem from the thermodynamic point of view. He concludes that a change in the constant of the law of mass action, due to isotopic differences, would probably be imperceptible unless suitable equilibria were examined under favorable conditions. As he puts it, isotopes could not be separated by an ordinary precipitation reaction, any more than nitrogen and oxygen could be separated by dropping liquid air into a red-hot flask.

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[1] L. Aronberg, Astrophys. J. **47**, 96 (1918).

[2] T. R. Merton, Proc. Roy. Soc. (London) **96A**, 388 (1920); **100A**, 84 (1921); B. Perretta, Compt. rend. **180**, 1589 (1925).

[3] F. W. Loomis, Nature **106**, 179 (1920); Astrophys. J. **52**, 248 (1920); A. Kratzer, Zeit. f. Physik **3**, 460 (1920).

[4] F. A. Lindemann and F. W. Aston, Phil. Mag. [6] **37**, 523 (1919); F. A. Lindemann, Ibid. [6] **38**, 173 (1919).

There is a highly speciallized type of reaction that seems to fulfill the conditions thus imposed for the separation of isotopes by chemical fractionation. If a single molecule, containing two isotopic atoms of the same element linked together, is capable of ejecting one of these atoms by thermal vibration, then it is plausible to assume that one isotopic variety might be more easily eliminated than the other. Though the effect of mass would be extremely small, it is conceivable that it might exert a deciding influence in cases where all other factors are balanced.

The action of a Grignard reagent on lead chloride, as discovered by Pfeiffer and Truskier[1], is an example of this type of reaction. The stoichiometrical relations are expressed by the equation

$$2PbCl_2 + 4RMgX = Pb + R_4Pb + 2MgCl_2 + 2MgX_2.$$

It has been shown[2] that R_2Pb is one of the intermediates in this reaction and that this compound is partially polymerized to R_2PbPbR_2. This latter compound, we assume, can break down with the production of metallic lead and the tetravalent organo-lead compound:

$$R_2PbPbR_2 = Pb + R_4Pb.$$

The use of this reaction to achieve a partial separation of isotopes has been investigated with conflicting results. Hofmann and Wölfl, Ebert and Dillon, Clarke and Hinchy[3] claimed that they obtained a change in isotopic composition while Staehling and Brennen[1] reported negative results. The author began his study of this reaction in his private laboratory in 1917[2]. More pressing duties interrupted the work until after the close of the war, when the investigation was resumed under the direction of Professor T. W. Richards at the Wolcott Gibbs Memorial Laboratory, Harvard University. A sample of lead chloride was fractionated several times using the Grignard reagent, phenyl magnesium bromide. It was hoped that a method of comparative density determinations could be developed that would indicate extremely small differences in isotopic composition. After a year's unfruitful experimentation in this direction, this method of attack was dropped. More recently the samples have been analyzed by determinations of the ratio $PbCl_2:2Ag$ by L. P. Hall[3]. He found that the atomic weight of the lead from the extreme metallic lead fraction was 207.217 and from the extreme tetraphenyl lead fraction 207.219, a difference of one part in a hundred thousand. These results were within the limits of experimental accuracy. They finally dispose of the claims of previous investigators that a considerable separation of lead isotopes may be effected with the aid of the Pfeiffer-Truskier reaction. They do not settle definitely whether a difference of mass is without effect in determining the course of the reaction. In the author's opinion, the difference to be expected would be less than could be indicated even by these extremely accurate atomic weight determinations.

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[1] P. Pfeiffer and P. Truskier, Ber. **37**, 1125 (1904).

[2] E. Krause and G. G. Reissaus, Ber. **55**, 888 (1922); S. Möller and P. Pfeiffer, Ibid. **49**, 2441 (1916).

[3] K. A. Hofmann and V. Wölfl, Ber. **40**, 2425 (1907); G. Ebert, Ion **2**, 277 (1910); T. Dillon, R. Clarke and V. M. Hinchy, Sci. Proc. Roy. Soc. (Dublin) **17**, 53 (1922).

Methods of Fractionation.—Mercury is a peculiarly suitable material for the determination of minute changes in the isotopic ratio. It is easily purified, and its density can be obtained to within one part in a million. Aston[4] has proved the isotopic complexity of this element, his revised figures for the mass numbers of its isotopes being 198, 199, 200, 201, 202 and 204.

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[1] C. Staehling, Compt. rend. **157**, 1430 (1913); H. Brennen, Ibid. **180**, 282 (1925).

[2] T. W. Richards and W. C. Schumb, J. Am. Chem. Soc. **40**, 1409 (1918).

[3] T. W. Richards, H. S. King and L. P. Hall, J. Am. Chem. Soc. **48**, 1530 (1926).

[4] F. W. Aston, Nature **116**, 208 (1925).

Moreover, many of its compounds containing two mercury atoms are unstable, breaking down to form metallic mercury and a mercuric derivative, reactions similar to that of Pfeiffer and Truskier previously discussed. The basic equation for this type of reaction,

$$Hg_2X_2 = Hg + HgX_2,$$

has been made the subject of a previous paper[1]. It was there pointed out that there were two possible structural formulae for mercurous compounds, X—Hg—Hg—X and $Hg{=}HgX_2$. If the first of these formulae is correct, then the course of the decomposition must be the same as for R_2PbPbR_2. With the second, however, it would seem that only one of the mercury atoms is free to take the metallic form unless there is a shifting of the X groups back and forth from one mercury atom to the other.

In order to determine whether there is any separation of isotopes in this simultaneous oxidation-reduction type of reaction, five series of fractionations were employed, the conditions being varied as much as possible. The mercury compounds used in these reactions were from the same source. No hesitancy would have been felt, however, in employing material from various unknown sources because, as has already been noted, the atomic weight of mercury from different sources is invariable, and because a difference, if any, in the atomic weight of the initial mercury would not affect adversely the significance of the comparative density determinations of the fractionated samples.

The reactions on which were based the first four methods of fractionation are represented as follows:—

$$Hg_2I_2 \rightleftharpoons Hg + HgI_2$$
$$Hg_2(CN)_2 \rightleftharpoons Hg + Hg(CN)_2$$
$$Hg_2O \rightleftharpoons Hg + HgO$$
$$Hg_2Cl_2 \rightleftharpoons Hg + HgCl_2$$

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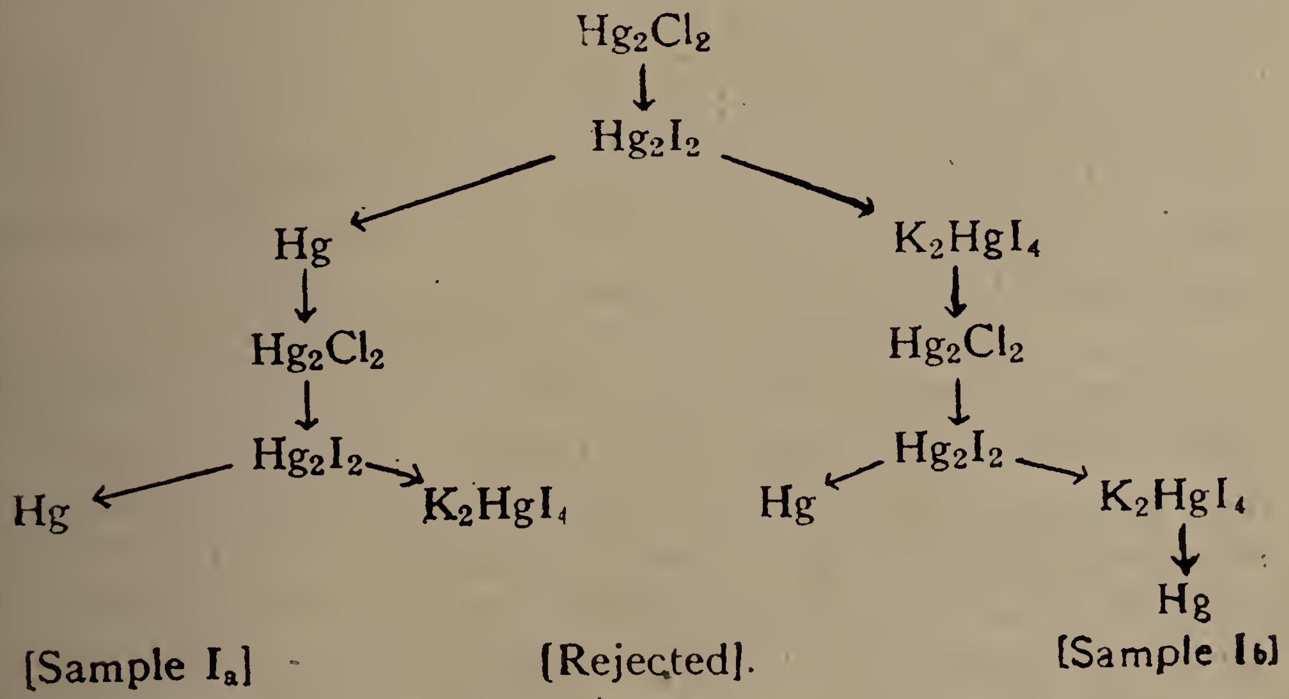
[1] H. S. King, Trans. Nova Scotian Inst. Sci. **16**, Pt. 3, (1924).

In the fractionation by the iodide treatment, mercurous chloride was made to a paste with water and a solution of potassium iodide added gradually. Mercurous iodide first formed. The equilibrium between this compound on one hand and mercury plus mercuric iodide on the other was shifted by the addition of further portions of potassium iodide solution. This removed mercuric iodide by the formation of potassium mercuriiodide, leaving a heavy gray sludge of finely divided mercury. The solution was decanted from the residue. After washing first with potassium iodide solution and then with water, the latter was coagulated into a globule by drying. The combined solutions were digested with metallic zinc and hydrochloric acid until all mercury had been reduced to metal. This mercury was shaken with dilute nitric acid until a small amount of mercurous ions was found in solution, in order to remove the major part of the zinc. The two samples of mercury thus obtained were separately converted to mercurous chloride by the ammonium formate method described under the heading, —purification of samples. These two samples of mercurous chloride were treated as before, the complete system of fractionation thus being



The fractionation by the cyanide method was the same as by the iodide except that mercurous chloride was added to an excess of potassium cyanide solution. In this way the mercurous cyanide was decomposed as rapidly as formed to give mercury and potassium mercuricyanide. The object of this method was to bring about as rapid a separation as possible.

In the case of the oxide fractionation, a very slow decomposition was desired. The mercurous chloride was added to an excess of dilute sodium hydroxide solution and allowed to stand for some days with frequent shaking. The precipitate of mercurous oxide, after careful washing, was gradually heated, out of contact with air, to decompose it into mercury and mercuric oxide. Finally potassium cyanide solution was added to dissolve the mercuric oxide.

The fourth method involved the use of aqua ammonia to shift the equilibrium

$$Hg_2Cl_2 \rightleftharpoons Hg + HgCl_2$$

to the right, the mercuric chloride reacting to produce infusible white precipitate. The mechanism has previously been discussed.[1] Several preliminary experiments, with the object of separating the mercury and the infusible white precipitate, were made. It was found that centrifugal separation was not complete and that volatilization of the mercury in a current of air was too slow. It was finally decided that extraction with a hot, concentrated solution of ammonium chloride was most efficient. By this treatment the infusible white precipitate was probably converted into fusible white precipitate.

$$Hg(NH_2)Cl + NH_4Cl = Hg(NH_3)_2Cl_2.$$

The two fractions obtained by each of these methods were converted to mercurous chloride and refractionated. The extreme metallic fraction in each case constituted the "a" sample itemized in the accompanying list. The mercury in solution in the other extreme fraction was reduced to the metallic state by means of zinc and hydrochloric acid. After removal of the excess of zinc by shaking with dilute nitric acid, these fractions were designated "b" samples.

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[1] H. S. King, Trans. Nova Scotian Inst. Sci. 16, Pt. 3, (1924).

The fifth reaction was similar to the Pfeiffer-Truskier reaction with the substitution of mercurous chloride for lead chloride.

$$Hg_2Cl_2 + 2C_2H_5MgBr = Hg + (C_2H_5)_2Hg + MgCl_2 + MgBr_2$$

To bring about this reaction, the directions of Marvel and Gould[1], with certain modifications, were followed. In order to insure as nearly complete reaction as possible the mercurous chloride in ether suspension was introduced directly into the Grignard reagent by means of a dropping funnel. Mechanical stirring also aided in keeping the material in finely divided form. The proportion of reagents was altered so that, instead of about 4.5 moles of the Grignard reagent per mole mercurous chloride as directed, the ratio was 10:1. In the purification of the products, the method used by Marvel and Gould, namely extraction with ether, was attempted. There was some trouble with metallic mercury passing through the filter so a small amount of finely divided copper was added to prevent this. However the extraction method had to be abandoned because of the risk involved in working with such large quantities of so toxic a compound as diethyl mercury (over 200 grams). Instead steam distillation was employed and found eminently satisfactory. In the distillate, the layer of diethyl mercury, dissolved in ether, was heavier than the supernatant water. This was allowed to stand for a long time uncovered, the ether gradually evaporating. The layer of diethyl mercury was then separated. The yield was about 50% of theoretical based on mercurous chloride used. By long boiling with a reflux condenser, the compound was decomposed into metallic mercury. The product was then distilled through a combustion tube containing hot copper oxide to ensure complete decomposition of the organo-mercury compound. Because of the danger involved in working with organo-mercury derivatives the fractionation was not repeated. The two fractions obtained in this way contained copper which was removed by dissolving the samples in nitric acid and precipitating mercuric sulphide from a solution of the nitrates in the presence of an excess of potassium cyanide. The filtered and washed sulphide was converted t bromide by the action of bromine and finally reduced to meta with zinc. After the removal of excess zinc by shaking wit dilute nitric acid, these samples were ready for the final purification.

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[1] C. S. Marvel and V. L. Gould, J. Am. Chem. Soc. 44, 153 (1922).

In addition to the fractions obtained by the above fiv methods, a sample of ordinary unfractionated mercury wa taken. This was prepared from the mercurous chloride by reduction with ammonium formate.

LIST OF SAMPLES.

S = Ordinary mercury, unfractionated.
I_a = Mercury from extreme Hg fraction of iodide treatment
I_b = " " K_2HgI_4 " " "
II_a = " " Hg " cyanide "
II_b = " " $K_2Hg(CN)_4$ " " "
III_a = " " Hg " oxide "
III_b = " " HgO " " "
IV_a = " " Hg " ammonia "
IV_b = " " NH_2HgCl " " "
V_a = " " Hg " Grignard "
V_b = " " $(C_2H_5)_2Hg$ " " "

Purification of the Samples.—Each of the samples enumerated in the above table was purified in the same way by a series of operations, both chemical and physical, which is summed up under the following headings.

1. Conversion of the sample to mercuric chloride and precipitation as mercurous chloride by the action of ammonium formate.
2. Further reduction to metal by ammonium formate.
3. Preparation of mercuric chloride by burning in chlorine and three fractional volatilizations of the product.
4. Reduction to mercury by ammonium formate.
5. Distillation of the metal four times in a stream of air under reduced pressure.

A discussion of the objects of these various steps together with the details of the technic follow.

All reagents used were carefully purified. Ordinary distilled water of the laboratory was twice distilled, first from alkaline potassium permanganate and then with the addition of a few drops of sulphuric acid. The condensers used were of block tin and had been thoroughly steamed out before use. The water was collected in pyrex flasks which had been filled with water and boiled for several hours before steaming out. Dust was excluded by suitable adapters. The nitric and formic acids were redistilled, the first and last quarters being rejected. In the case of hydrochloric acid the middle third only was collected for use. The ammonia was distilled either directly into the diluted formic acid to convert it into the ammonium salt or absorbed in water. The chlorine was prepared by dropping pure hydrochloric acid onto the "C. P." potassium permanganate of a reliable house. The gas was first washed with water and then dried by two wash bottles of concentrated sulphuric acid and finally by a tower of solid glass beads down which a stream of sulphuric acid trickled. With a few unimportant exceptions, all glass used throughout the investigation was of pyrex, which had been thoroughly cleaned and steamed out.

In the purification of the mercury, each sample (about 150 grams) was oxidized with nitric acid. The mercuric nitrate, so produced, was converted into chloride by several evaporations with hydrochloric acid. The solution was evaporated to dryness, and the residue dissolved in water. An excess of aqueous ammonium formate was added, and the solution warmed. There was a copious evolution of carbon dioxide, and pure white mercurous chloride was precipitated. The reaction was not quite quantitative. The product was filtered, and the precipitate well washed. This precipitate was treated with an excess of ammonium formate solution, and the mixture boiled. From time to time portions of aqua ammonia were added. The reduction is much more rapid and complete in an alkaline medium. Metallic mercury was precipitated in a finely divided form. It was well washed by decantation. On drying, the mercury coalesced into one globule. There was a tendency for this globule to wet glass surfaces. After pouring the product through a fine glass capillary, the scum causing this wetting was removed.

This reduction, carried out first in a neutral or slightly acid medium, and then in an alkaline, must have effected a considerable purification. Though silver and gold were not removed the less electronegative elements must have been separated quantitatively. To test this conclusion, a solution of the chlorides of mercury and copper was reduced in the same way as described above. Five grams of the mercury precipitated were dissolved in nitric acid, evaporated to dryness and ignited in a pyrex beaker. Silver was found in the almost invisible white residue, but the ferrocyanide test for copper was negative. Since copper was known to be present in some of the initial samples, this result was reassuring.

The mercury, after the ammonium formate purification, was introduced into the first of a series of four pyrex bulbs. This first bulb was enclosed in an asbestos hot air bath. Pure, dry chlorine was passed over the mercury until the reaction was practically complete. Then the temperature was adjusted so that the molten mercuric chloride gently volatilized. The vapor was carried by a stream of chlorine into the second bulb where it condensed. A small residue, consisting largely of mercuric chloride, was left behind. In the same way two more volatilizations were made.

In a preliminary experiment with a sample of mercury known to contain traces of iron, there was a faint pink tinge to the mercuric chloride. In the fractionation of the pure mercury samples, the product was without a trace of color. This series of fractional volatilizations would not have removed the more volatile chlorides that might have been present. Rose[1] has shown that auric chloride volatilizes easily in a current of chlorine at temperatures ranging all the way from 180° to 1100°C. Thus this treatment would not have freed the product from gold. However the following tests show that silver must have been left quantitatively in the residue. The first bulb was extracted, first with hydrochloric acid and then with ammonia.

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[1] T. K. Rose, Trans. Chem. Soc. (London) **67**, 881 (1895).

The combined extracts were evaporated to dryness and ignited. A faint white residue contained silver. By similar treatment no silver could be extracted from the second bulb. It might be noted here that, after each series of volatilizations, each bulb was extracted with hydrochloric acid and ammonia. Finally, before reassembling, they were well steamed out.

In order to recover the mercury in metallic form, the thrice volatilized mercuric chloride was dissolved in water and reduced to metal by the ammonium formate method. The process was much the same as in the previous reduction except that mercurous chloride was not isolated. This metal was distilled four times in a partial vacuum in a current of air by Hulett's method.[1] Special care was taken in designing the still to prevent the passage of spray into the condenser. With this object in view, a fractionating column of zig-zag form was inserted between the still and condenser.

Hulett has shown that, by the distillation of mercury in a stream of rarefied air, all readily oxidizable metals such as zinc, cadmium, bismuth, tin, copper, lead, etc., are completely removed by oxidation in the vapor state. On the other hand, several distillations are necessary to reduce the amount of silver, gold and platinum to a point where their presence cannot be detected. After one distillation Hulett found 2 parts of silver, 0.027 part of gold and 0.001 part of platinum per million parts of the distilled mercury. A second distillation reduced the amount of silver to 0.03 part and of gold to much less than 0.01 part. A third distillation reduced these impurities to a non-detectable amount. Thus it is seen that silver is distinctly the most difficult to remove by this method. It is for this reason that mercuric chloride was fractionally volatilized prior to the distillation of the metal.

It is possible that part of the metallic impurity in the distillate found its way thither as spray. In the form of still used in our purification, the partial condensation of mercury in the fractionating column must have completely freed the vapor from any spray arising from the distilling flask. It is probable, though no tests were made to prove this point, that the condensed mercury carried back with it any noble metal that may have volatilized. In this way, one distillation should have been as efficacious in removing these impurities as several distillations without the fractionating column.

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[1] G. A. Hulett, Phys. Rev. **33**, 307 (1911).

The mercury samples after passing through the various steps in the purification described above were drawn by suction several times through extremely fine capillaries and collected in scrupulously cleaned weighing bottles in order to remove every possible particle of dust.

If gases from the atmosphere are absorbed by mercury, an error would be introduced into the density determinations, though it would be more or less canceled out because there is no reason to suppose that one sample would absorb more than another. Hulett[1] has discussed this possibility. He referred to three barometers which had been under observation for over thirty years by the Weather Bureau at Washington. After this period of time, they gave the same readings as new barometers to within 0.05 mm. This very neat observation gives some idea of the insolubility of atmospheric gases in mercury.

It is recognized that, in some step or steps in the purification, a partial separation of isotopes might have taken place. Therefore all samples were treated as nearly alike as possible. In this way any such separation would be the same for all and without influence on the comparative densities determined.

Density Determinations.—There is an accumulation of evidence upholding the view that the densities of isotopically different samples of the same element vary directly with the statistical atomic weights[2]. Although this relationship may not be exact, its deviation must be almost infinitesimal. For measuring the amount of separation effected by various processes, the exact ratio between density and atomic weight has been, perhaps, too implicitly relied upon. For determining whether any separa-

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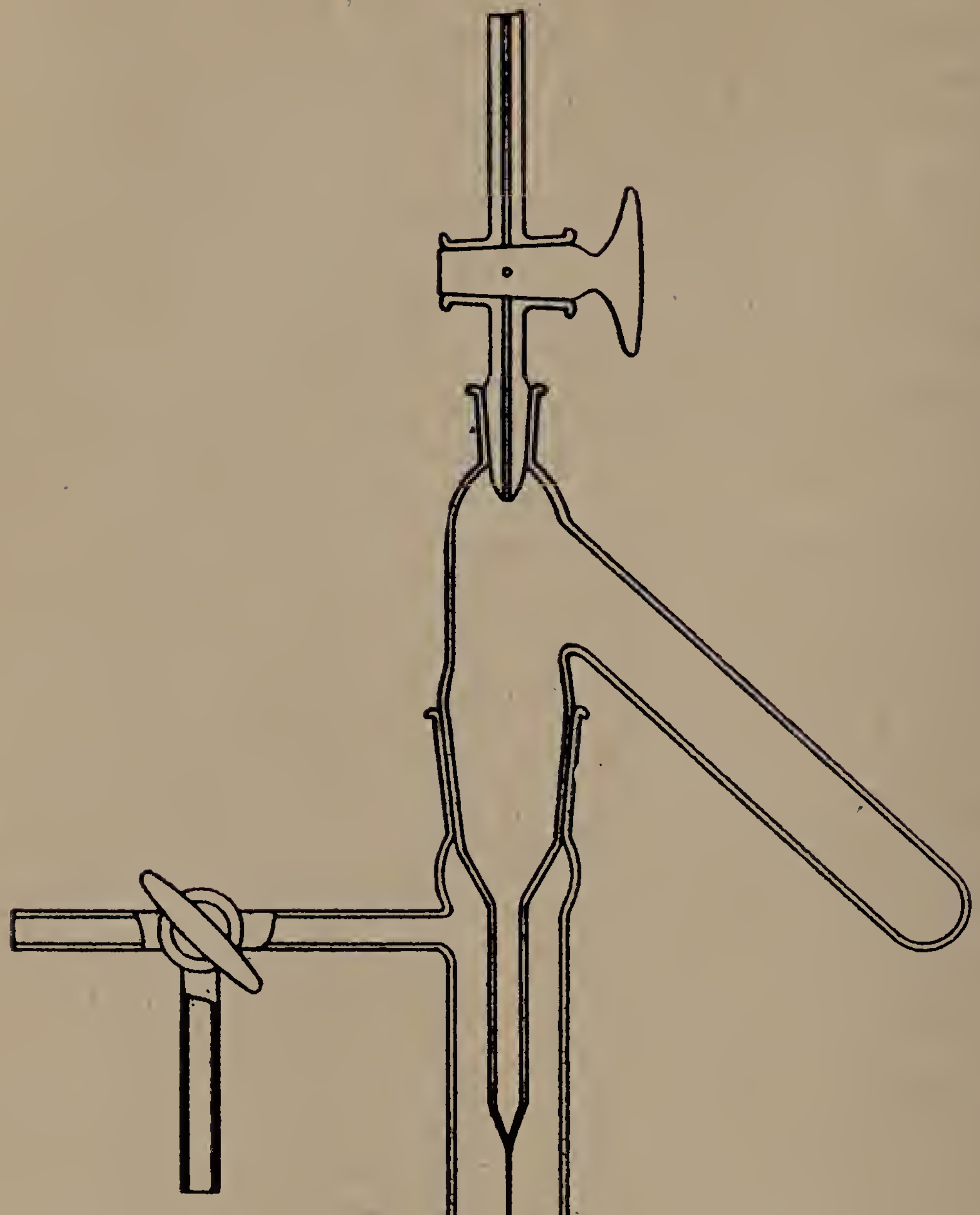
[1] G. A. Hulett, Phys. Rev. **33**, 313 (1911.)

[2] F. Soddy, Nature **94**, 1615 (1915); **107**, 41 (1921); T. W. Richards and C. Wadsworth, J. Am. Chem. Soc. **38**, 221 and 1658 (1916); J. N. Brönsted and G. Hevesy, Z. physik. Chem. **99**, 189 (1921); W. D. Harkins and A. Hayes, J. Am. Chem. Soc. **43**, 1803 (1921); R. S. Mulliken and W. D. Harkins, Ibid. **44**, 37 (1922).



tion has taken place, the density method is admirable. If the two extreme samples obtained by a process of fractionation do not differ in density, then that process does not effect any appreciable separation of isotopes.

For determining the density of the samples fractionated by chemical means and purified by the methods just described three pyknometers were employed. These pyknometers were made from the same length of pyrex tubing nearly a year prior to their use in order to allow for the contraction of glass after fusion. Their dimensions were as nearly identical as possible. The diameters of the capillary necks of two of these pyknometers were 0.2 mm. In the third one, used later as tare, this dimension was slightly larger, about 0.25 mm. The weights of all three were the same to within 0.01 g. and the volumes to within 0.03 c.c.

The pyknometers were filled in the manner to be described by the use of an apparatus illustrated in the accompanying cut. The pyknometer, resting in a holder, was lowered into the apparatus, care being taken to cover the greased glass joint with glazed paper to prevent contamination from this source. Then the extremely fine capillary on the stopper was inserted into the neck of the pyknometer. The mercury sample was introduced into the side arm of the stopper and the whole apparatus exhausted through both stopcocks. Then by tipping the apparatus the mercury was brought into the stem of the stopper. It is necessary to exhaust the stopper as well as the pyknometer chamber prior to this transference of the mercury in order to prevent bubbles of air from being carried into the pyknometer. Air so introduced is extremely hard to remove especially in the latter stages of the filling when the end of the capillary tube is submerged. When the vacuum in the stopper had been broken, the mercury began to drop very slowly through the capillary into the pyknometer. After this had been filled, there still remained a portion of the mercury in the reservoir. Air was then admitted gradually, and the pyknometer removed.

Since a change of 0.001°C in temperature changes the specific gravity of mercury by 0.000002 unit, the amount of mercury in the pyknometer was adjusted at a definite temperature maintained as nearly constant as possible. The filled pyknometer was inserted into a long, thin glass test tube and lowered into a padded and covered thermostat tank. The temperature was controlled by a six-fingered toluene regulator holding about a liter of toluene[1]. At the suggestion of Dr. John Russell, while a student at Harvard, a roll of fine copper gauze was inserted in each of these fingers to bring about a more rapid heat transfer. Toluene itself is a poor conductor of heat. Ordinarily only the outer layer expands or contracts with changes of temperature. This modification was very satisfactory, the lag being less than with the ordinary type, as shown by the rapidity with which the electric light bulb, used for heating, flashed on and off. This regulator kept the temperature at approximately 29.0° to within 0.001°C. No change in the reading of a Beckman thermometer, on which a thousandth of a degree could be estimated, was noted. After several hours at constant temperature, the drop of mercury expelled was removed by drawing across the smooth top of the capillary a small sliver from a safety razor blade cemented at right angles to the end of a wooden rod. Then the pyknometer was removed. After coming to room temperature, the droplets of mercury on the surface of the pyknometer were removed by brushing the surface with a camel's hair brush. Some trouble was experienced here because of the electric charge given to the glass. This was avoided by brushing the pyknometer inside a box in which a large quantity of radioactive uranium salt was strewn, the charge being dissipated by the ionized air. It is hardly necessary to state that the pyknometers were never touched with the fingers, cork-tipped forceps always being used.

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[1] The toluene was a sulphur-free sample which was further purified, washed with water and dried with sodium. Molten sodium was run into the hot toluene and the mixture shaken until the sodium solidified in the form of minute globules. Sodium in this form is much freer from surface oxidation than that exuded as wire from a press. The toluene was then distilled, the vapor passing through a trap containing liquid sodium-potassium alloy. These precautions were taken to eliminate the possibility of impurities reacting with the copper coils in the regulator.

When not being weighed, they were kept under a bell jar and carefully protected from dust or contamination of any kind.

It has been stated that three pyknometers were made. One of them filled with pure mercury from sample "S", served as a tare throughout the series of weighings. In each series of determinations (designated I, II, III, etc.) the two other pyknometers (designated by the prime numerals "1" and "2") were used. One was filled with sample "a", and the other with sample "b", obtained from one of the series of fractionations. These two samples were then brought to the standard temperature and the exuded drops of mercury removed at the same time. Thus even if the temperature of the bath had varied slightly, the error would have been the same for both and consequently negligible. These two samples were then weighed, one immediately after the other, against the first pyknometer as tare. Since the tare used was so nearly identical in composition, proportions and weight to the pyknometers plus samples, errors due to temperature, surface adsorption and pressure differences were eliminated to a great extent. The tare and sample during the weighings rested on supports made from the same piece of glass rod and identical in weight to within one milligram.

After this first weighing the pyknometers were emptied and filled again with the same samples reversed and adjusted to standard temperature. That is, if, in the first weighing, sample 'a" was in pyknometer "1" and sample "b" in pyknometer "2", then in the second set of weighings sample "a" was in pyknometer "2" and sample "b" in pyknometer "1". In this way, it was felt, all irregularities introduced by temperature changes, etc., were eliminated.

The balance used was a Troemner No. 10, which was purchased especially for this investigation and used for no other purpose. The sensitivity of the balance was adjusted so that 0.1 division of the scale was equivalent to approximately 0.015mg . Three weighings and a determination of the sensitivity were made for each determination. The averages are given in the accompanying table. The extreme variation between these weighings for any particular sample was 0.05 mg. This extreme variation was rare. Since in all six weighings (three in one pyknometer and three in the other) were made with each sample the error due to weighing was within 0.01 mg.

Before weighing the fractionated samples, a set of determinations for comparison purposes was made using portions of the same standard sample "S" in each pyknometer. The result of this series shows that pyknometer "1" filled with mercury weighed 0.35308 gram and pyknometer "2", 0.06915 gram less than the tare. The total weight of mercury in the tare was approximately 72.0 grams.

The data obtained, together with the densities calculated (assuming unity for the density of ordinary mercury) follow. Tare = τ.

Sample	Weight	Av. Weight.
S^1	τ—0.35310	τ—0.35308
	τ—0.35305	
S^2	τ—0.06911	τ—0.06915
	τ—0.06919	

Sample	Weight	Density	Av. Density	Diff. in Density. Parts in 10,000,000
I^1_a	τ—0.35322	0.9999980	0.9999988	—6
I^2_a	τ—0.06917	0.9999997		
I^1_b	τ—0.35314	0.9999992	0.9999994	
I^2_b	τ—0.06918	0.9999996		
II^1_a	τ—0.35309	0.9999999	1.0000001	±0
II^2_a	τ—0.06913	1.0000003		
II^1_b	τ—0.35309	0.9999999	1.0000001	
II^2_b	τ—0.06913	1.0000003		
III^1_a	τ—0.35310	0.9999997	1.0000024	+19
III^2_a	τ—0.06878	1.0000051		
III^1_b	τ—0.35296	1.0000017	1.0000005	
III^2_b	τ—0.06920	0.9999993		
IV^1_a	τ—0.35300	1.0000011	1.0000010	+6
IV^2_a	τ—0.06909	1.0000008		
IV^1_b	τ—0.35319	0.9999985	1.0000004	
IV^2_b	τ—0.06899	1.0000022		
V^1_a	τ—0.35308	1.0000000	1.0000010	—18
V^2_a	τ—0.06900	1.0000021		
V^1_b	τ—0.35278	1.0000042	1.0000028	
V^2_b	τ—0.06904	1.0000015		

The average deviation of these weighings from the mean is 0.08 mg. With two exceptions, III_a^2 and V_b^1, the maximum deviation from the mean is 0.15 mg. In both these exceptional cases, the weights were high. This effect might have been due to an unseen droplet of mercury on the outer surface of the pyknometer or to incomplete removal of the expelled droplet of mercury after adjusting the temperature in the thermostat. However we have included these figures. If these two exceptions had been rejected, the difference in density between the two extreme fractions in the third and fifth series would be —8 and —5 instead of +19 and—18 parts in 10,000,000. The results show that certainly in none of the chemical methods of fractionation tried was there a difference in density between the extreme fractions of more than 2 parts in a million and probably none greater than 1 part in a million. From these results the greatest change in atomic weight of mercury in any one of the samples analyzed must be less than 0.0002 unit.

A STUDY OF EARLY DEVELOPMENT IN CUMINGIA WITH SPECIAL REFERENCE TO CYTOLOGY.—BY MARGARET ELIZABETH MACKAY, B. A., M. A., Assistant in Histology and Embryology, Dalhousie University, Halifax, N. S.

(Presented 17 May 1926)

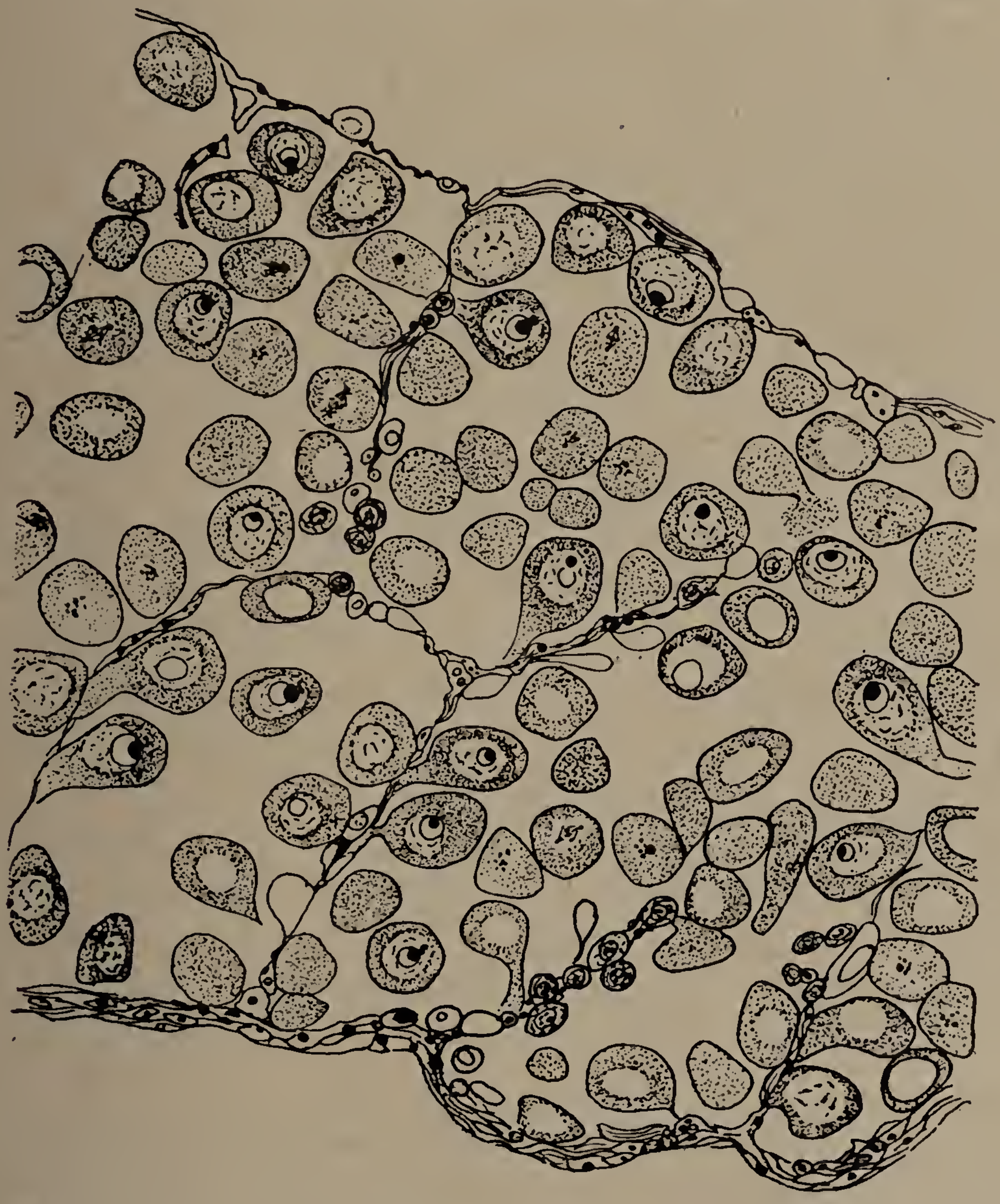
The purpose of this paper is a description of the changes which take place in the egg of *Cumingia* (Sowerby, 1833) from the primary oöcyte, through maturation, fertilization and segmentation up to the four celled stage. A cytological study of this egg was made by Jordan in 1910, in which particular attention was paid to the history of the chromosomes and the centrosomes. Since the publication of Jordan's paper, a great many workers have used the *Cumingia* egg for experimental purposes, but, in practically every instance the experimental work has not been checked up by cytological evidence. In order that future investigators working with this material experimentally, may have a clearer conception of the early development stages of the normal egg, the present paper was written with the idea of repeating Jordan's work and in addition, making a cytological analysis of fertilization.

The material was collected by Professor R. J. Bean at the Marine Biological Laboratory, Woods Hole, Mass., in the summer of 1923. The eggs were fixed in Bouin's fluid, sections cut 5μ in thickness, and stained by the iron-alum haematoxylin method. Starting with sections of ovary, the series contains the following material:

Eggs collected at the moment of shedding.
Eggs taken from sea water from 10-30 minutes after shedding.
Eggs allowed to grow stale in sea water from 3-4 hours.
Inseminated eggs fixed 5 sec., 10 sec., 15 sec., 30 sec., 45 sec., respectively after exposure to a sperm suspension.
Inseminated eggs fixed at intervals one minute apart, from 60 secs. to 1 hour and forty-five minutes.

Acknowledgement is hereby made to Professor Bean who prepared most of the slides and whose advice has been very valuable in the preparation of this paper.

The ovaries of Cumingia are symmetrical, paired structures which occupy the posterior portion of the visceral mass (Fig. 1).



Ovaries with eggs in different stages from the primary oöcytes to the mesophase of the first maturation division.
[Figs. 2 to 14 at the end.]

Each is covered with a capsule from which trabeculae extend dividing the organ into acini. The latter are filled with eggs in varying stages of development, from the primary oöcytes to the mesophase of the first maturation division. The ova, which develop from cells in the ovarian epithelium, are irregular in shape, due partly to pressure conditions within the ovary. The larger ovals are coated with jelly and rest attached to the ovarian wall at one point. This point of attachment represents the vegetal pole of the egg. Polarity is further marked by the tendency of the nucleus and nucleolus to take an eccentric position near the free surface of the egg, thereby establishing a true animal pole.

No signs of oögonial division could be found in the ovaries, though primary oöcytes were abundant. These oöcytes are spherical in shape and consist largely of nucleus, in the centre of which is an irregular mass of chromatin surrounded by a light network. As growth takes place the cytoplasm increases in volume more rapidly than the nucleus, becoming coarsely reticular and showing small black granules. Within the nucleus is a spherical nucleolus surrounded by several chromatic masses. When the oöcyte reaches a size about one half that of the full grown egg, the cytoplasm becomes finely granular, and the chromatic masses in the nucleus aggregate into an irregularly shaped body which is situated close to the nucleolus and lies between it and the nuclear membrane.

At a somewhat later stage in development, large spherules which stain very deeply with haematoxylin, appear scattered throughout the granular cytoplasm. The nucleus is large and well defined, showing a light achromatic reticulum and enclosing both the spherical nucleolus and the irregular outlined chromatin knot. The latter, now lies in contact with the nuclear membrane as well as the achromatic capsule of the nucleolus (Fig. 2). The nucleolar capsule presents a most striking figure at this stage of development. It is nearly twice the diameter of the nucleolus and because of this fact, the nucleolus assumes an eccentric position within its capsule.

Shortly before the breaking down of the germinal vesicle, the nucleolus is cast out bodily into the nucleus by rupture of the surrounding envelope (Fig. 3). This capsule disappears shortly after the nucleus breaks down and its further history cannot be traced. The nucleolus, spherical in shape and slightly decreased in size, retains its identity after the chromosomes are formed, though it is gradually absorbed by the cytoplasm and disappears before the anaphase (Fig. 4). This may indicate partial contribution of nucleolar substance to the chromosomes as Jordan, 1910, suggests. The chromatin body from the nucleus breaks down immediately upon rupture of the germinal vesicle and its fragments appear to enter the spindle. This is in accordance with Jordan who found what he considered as positive evidence, that this body was distributed to the chromosomes.

The changes subsequent to the breaking down of the germinal vesicle take place rapidly. The out-flowing of the more fluid nuclear sap into the cytoplasm is followed by the immediate appearance of the chromosomes. The centrosome arises simultaneously with the chromosomes and the asters for the first maturation spindle lie near the centre of the egg. Each centrosome has a large, deep staining centriole, surrounded by a paler centrosphere (Fig. 5). As the spindle undergoes mitotic changes for the metaphase, the centriole gradually becomes smaller and the centrosphere increases in size until finally the whole centrosome is achromatic and oval in shape (Fig. 6). It is very probable that the centriole is changed into the pale staining centrosphere. Jordan (1910) describes a fragmentation of the centriole but such fragmentation was not observed in this investigation. Lillie in 1898 found a similar case in *Unio* in which he expresses an opinion that the centrosome granules are transformed into the substance of the centrosphere. The black granule or centriole does not reappear in any of the following mitotic figures, although centrosomes are indiscernable during each intermitosis and appear anew with each mitosis.

Coincident with shedding, the irregularly shaped ovarian egg becomes spherical, though in many cases there is a conspicuous evagination of cytoplasm in the region of the vegetal pole (Fig. 5). This protuberance marks the point of attachment of the egg to the ovarian wall and disappears about 30 seconds after the eggs are cast into sea water (Fig. 6.) A very thin membrane which is barely visible under oil immersion encloses the egg, and no cytological evidence for the discontinuity of this membrane at the vegetal pole could be found. Hielbrunn, 1915, was also able to demonstrate the existence of such a membrane in Cumingia by using micro-dissection methods. At the time of shedding, the first maturation spindle is in the mesophase of first polar body formation; but no polar bodies are given off unless the egg is activated parthenogenetically or fertilized with a spermatozoön. Exposure to parthenogenic agents or to a sperm suspension will cause maturation to proceed, though no morphological changes are visible for two or three minutes.

Sperm Penetration.

Sperm penetration is very rapid in Cumingia and the initial processes are obscure. About three minutes after insemination there appears in the vegetal pole of the egg a small cone of cytoplasm. This is one of the first morphological evidences of fertilization and the sperm may often be seen embedded in the jelly on the tip of this fertilization cone. The sperm shortly penetrates the vitelline membrane and comes to lie within the cytoplasmic cone (Fig. 7). As the spermatozoön enters the cone its long axis is parallel to the axis of the cone, but it soon rotates through an angle of 90 degrees. As the spermatozoön becomes withdrawn from the fertilization cone its identity is temporarily lost because of the profusion of black cytoplasmic spherules which lie in the cortex of the egg. Therefore it was impossible to determine whether or not further rotation occurred. The work of Lillie, 1912; Meves, 1912-14; Boveri, 1898; and Wilson, 1896; seems to indicate that a rotation of 180 degrees is a more or less general phenomenon, and it is very probable that Cumingia does not differ in this respect from the majority of other forms. Since the tail of the spermatozoön could not be found attached to the fertilization cone, it is assumed that the entire spermatozoön enters the egg even though the tail as such could not be distinguished.

The position of the fertilization cone is always in the vegetal hemisphere and with a few exceptions is directly below the central pole of the spindle, opposite the region where the polar bodies are given off. Its location corresponds to the point of attachment of the egg to the wall of the ovary and also to the protuberance of the cytoplasm that appears after shedding. Though no micropile could be seen in this egg, it is certain that there is a restricted vulnerable area in the membrane, where the sperm enters, which is at the vegetal pole, and marks its point of attachment to the ovary. This view is permissible because in other Lamellibranchs where a micropile definitely exists, its position is approximately the same as the vulnerable area in Cumingia.

While the above process is taking place the vitelline membrane also undergoes certain changes. Occassionally after penetration of the sperm a tiny ragged marking remains in the jelly layer and vitelline membrane which indicates the point of sperm penetration, and in such cases a small quantity of cytoplasm flows out and the exudate together with the fertilization cone gradually flattens out and disappears. Before fertilization the membrane is almost indistinguishable, but after the entrance of the sperm it increases slightly in thickness and becomes clear and very slightly serrated (Fig. 6 and Fig. 7). No appreciable membrane elevation occurs under normal conditions, but Hielbrunn, 1915, demonstrated it experimentally by exposure of the egg to varying salt solutions.

The sperm, following penetration, undergoes certain definite changes in position and form. After its entrance into the egg, being temporarily obscured by the black cytoplasmic spherules, it appears between 5 and 6 minutes after fertilization as a spherical black chromatic mass slightly to one side of its point of entrance and close to the periphery of the egg (Fig. 8). It leaves no visible path in the cytoplasm but during maturation it changes its position with reference to the spindle, gradually moving toward the animal pole but remaining the same distance from the periphery of the egg. It usually comes to rest opposite the lower pole of the maturation spindle about ten minutes after fertilization, when the latter is in the anaphase of the first polar body.

During its migration the sperm undergoes the following morphological changes. Six minutes after penetration it appears considerably enlarged as a deep staining spherical body surrounded by a very narrow clear colorless zone of cytoplasm.

Two or three minutes later a new zone, pale grey in color, appears between the sperm and the clear zone of cytoplasm (Fig. 9). From this time up to a stage about 12 minutes after fertilization the greyish zone continually increases in width, while the deeply stained central portion diminishes until it is no longer distinguishable. From this stage on until the second polar body is formed the sperm may be seen at rest as a large grey spherule still surrounded by a zone of clear cytoplasm.

Following fertilization the spindle, which was resting in the mesophase, proceeds to maturation. The first noticeable change is a widening of the spindle and the arrangement of the chromosomes, thirty-six in number, in an equatorial plate. The form of the spindle changes distinctly upon insemination. Previous to insemination it is elongate and narrow and if the eggs are allowed to stale this condition becomes more and more pronounced. Within a very few seconds after insemination it becomes appreciably widened. Indeed the anaphase of the first polar body formation is quite definitely indicated before penetration of the sperm can be observed. It could not be determined whether the first polar division was reductional or equational. The polar bodies are given off at the chief axis of the egg, the elevation of the vitelline membrane is first apparent about six minutes after, though the first polar body is not actually formed for eleven or twelve minutes (Fig. 9). Eighteen chromosomes pass out in the first division and a surface view of the polar body shows them arranged radially in a ring. Those left behind, together with the centrosome, move up and lie under the first polar body.

The centrosome does not disappear during the formation of the polar bodies; but, like the chromosomes, retains its identity throughout the process of maturation, appearing as a pale central granule in the aster. The centrosome of the distal pole of the spindle passes out in the first polar body, while that left in the egg divides to form two asters and the second spindle. The axis of this second spindle is at first at right angles to that of the first spindle, but as it elongates a rotation of 90 degrees takes place. The two polar bodies remain attached to the egg for some time and may be seen through the early cleavages.

In the late telophase of the second maturation spindle, the chromosomes of the central pole become broken up, prior to forming the chromosomal vesicles (Fig. 11). There are several of these chromosomal vesicles, and Jordan suggests that there is one of the latter for each chromosome. These fuse later to form the kidney shaped female pronucleus.

Maturation is completed about 28 minutes after fertilization, although membrane elevation for the second polar body may be observed at a much earlier stage. Changes in the resting sperm closely follow the termination of maturation. It becomes larger and elongates until it assumes an arrow-head shape with the apex directed toward the center of the egg. At this stage the sperm changes its position moving a short distance toward the vegetal pole, leaving behind it a clear space which marks its former position. This clear vesicle in the cytoplasm only persists for a few moments and shortly becomes filled in with cytoplasm. About 30 minutes after fertilization, astral rays appear around the point of the arrow-head shaped sperm (Fig. 10). This is undoubtedly a typical sperm aster and may be seen actually attached to the sperm. This observation is in direct variance with the findings of Jordan who states that no sperm aster exists. At this stage the sperm shows a light chromatic network and is apparently a vesicular structure (Fig. 10). Three or four minutes later the arrow-head outline of the sperm is lost and it becomes first oval in shape and finally spherical.

About 33 minutes after fertilization both the male and female pronuclei are fully formed. They are spherical in shape and of the same size so that one cannot be distinguished from the other. Each shows a well defined nuclear membrane which encloses the delicately reticulated nuclear contents. As they approach the common meeting point, the fine reticulum of both appears to be knotted or beaded with chromatin material (Fig. 12). Just before the actual meeting of the pronuclei the reticulum breaks down and chromosal bodies are formed. At about the 38 minute stage the nuclear membranes come into contact with each other, fuse, and then break down along the line of fusion.

The origin of the asters for the first segmentation is somewhat doubtful. There is unquestionably a sperm aster, but, the central aster of the second maturation division also remains visible, near the female pronucleus, up until the time of fusion of the pronuclei. There is no evidence that either of these asters divide, neither do they disappear until after the anaphase of the first segmentation division. Therefore, it is probable that both asters are concerned with the formation of the first segmentation spindle.

The chromosomes which are formed from the pronuclei are much different in form from those observed in the early maturation stages. Each appears as a slender filament with a knot at one end. Upon fusion of the pronuclei, they become curled up in such a way as to resemble tiny signet rings. During the late anaphase of the first segmentation division they become compact and the shape of individual chromosomes varies considerably.

The axis of the first divisional spindle is at right angles to the polar axis of the egg and slightly eccentric so that the resulting cells are of definite size (Fig. 13). The nuclei of these cells resemble the male and female pronuclei, as they are oval in shape with no light chromatin network and no nucleolus or centrosome (Fig. 14). The latter arising suddenly with the spindles and chromosomes appears as a pale central granule of the aster. The plane of the second division is at right angles to that of the first and is in line with the polar axis of the egg, separating it into one large and three small cells. The asters and chromosomes are very similar to those of the first divisional spindle.

Summary.

1. The ovaries of *Cumingia* during the breeding season, contain eggs in all stages of development from the primary oöcyte to the mesophase of the first polar body information.

2. The ovarian eggs are attached by the vegetal pole, the animal pole being free and containing the nucleus and nucleolus.

3. The eggs are shed in the mesophase of the first polar body formation, but the first polar body is not given off unless the eggs be inseminated or activated artificially.

4. The first morphological signs of fertilization are the appearance of a fertilization cone and a widening of the maturation spindle.

5. There is but one vulnerable area for sperm penetration in Cumingia, and this area lies at the vegetal pole. There is no well defined micropyle.

6. The vitelline membrane is very thin and does not become appreciably elevated until the first polar body is given off.

7. Sixteen chromosomes pass out in the first polar body and sixteen in the second.

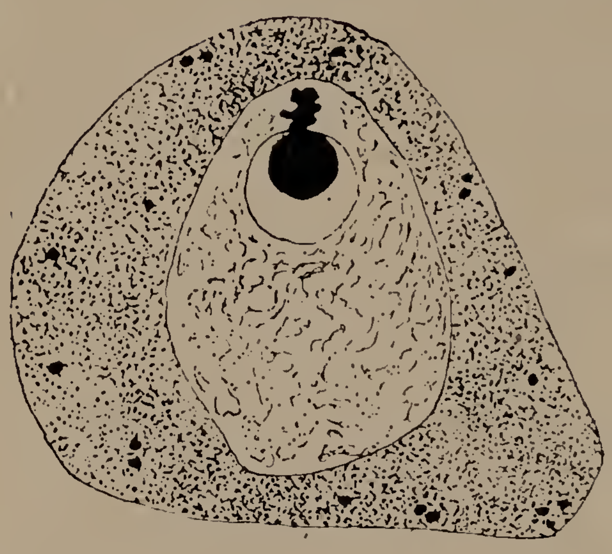
8. The sperm lies quiescent during the maturation divisions, after having migrated from the fertilization cones at the vegetal pole, to a position level with the equatorial plate of the first maturation spindle.

9. A large sperm aster is formed, but, the aster of the central polar spindle also remains visible and possible functions with the first segmentation spindle.

10. The position of the first segmentation spindle is such that the first segmentation is unequal and the resulting cells unequal in size.

11. It must be recognized that the time at which different morphological changes occur is variable for different batches of eggs, also, the speed at which any egg develops will depend a great deal upon the temperature of the water in which the egg is developing. On a very warm day development is much more rapid than on a cool day.

Description of Drawings.



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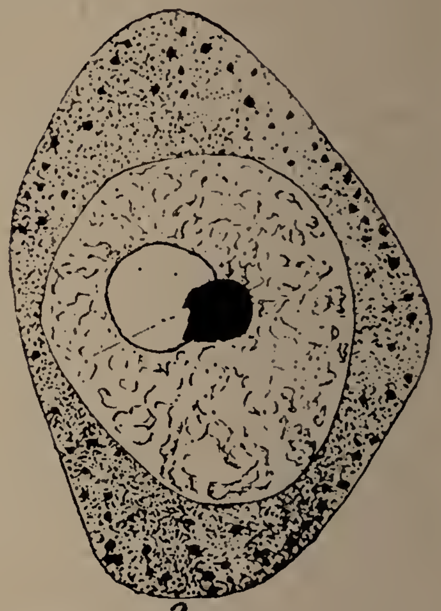
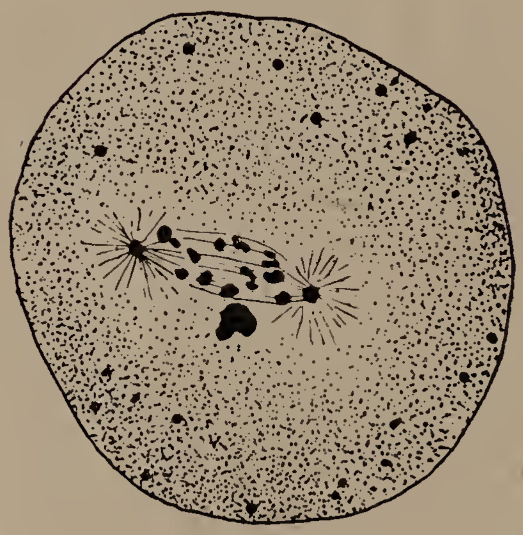


3.

2. Egg with intact germinal vesicle containing nucleolus in capsule with the chromatin knot outside.

3. Egg showing rupture of the nucleolar capsule.



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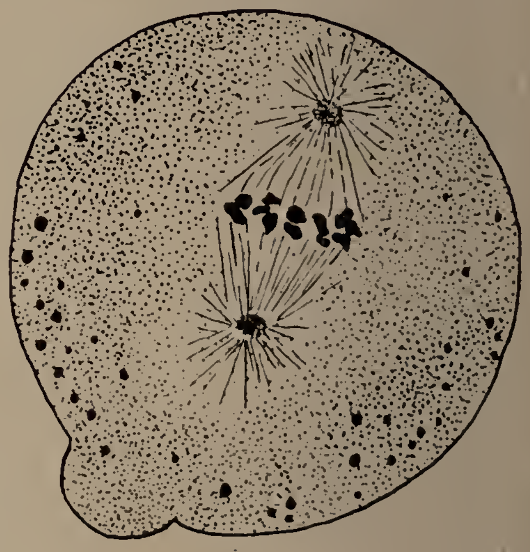

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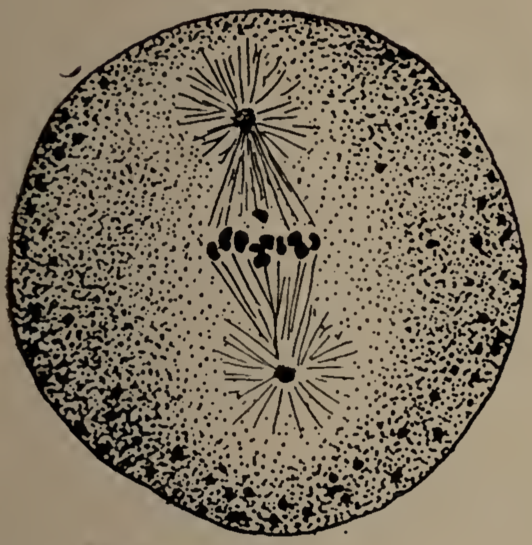
4. Egg after rupture of germinal vesicle showing formation of the spindle.

5. Egg immediately after shedding showing protuberance at the vegetal pole.



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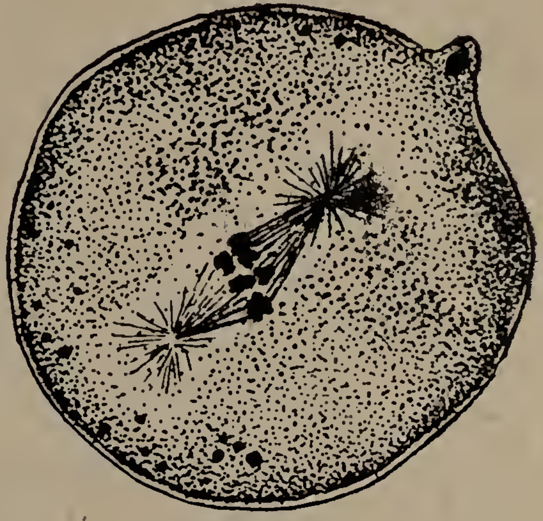

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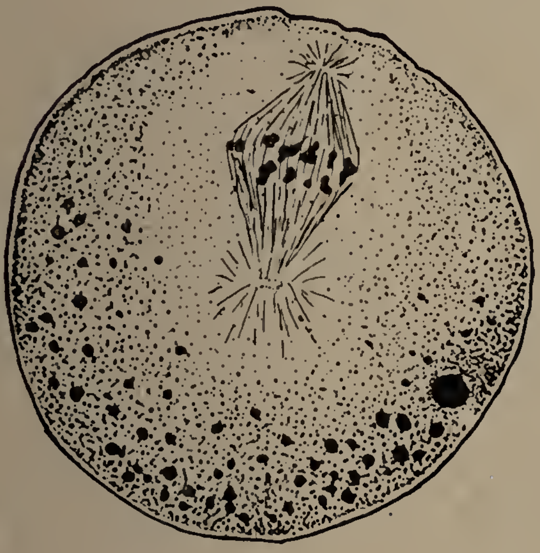
6. Egg thirty seconds after shedding, protuberance has disappeared and the centrosome is achromatic.

7. Egg with fertilization cone and sperm showing swelling of the vitelline membrane following fertilization.



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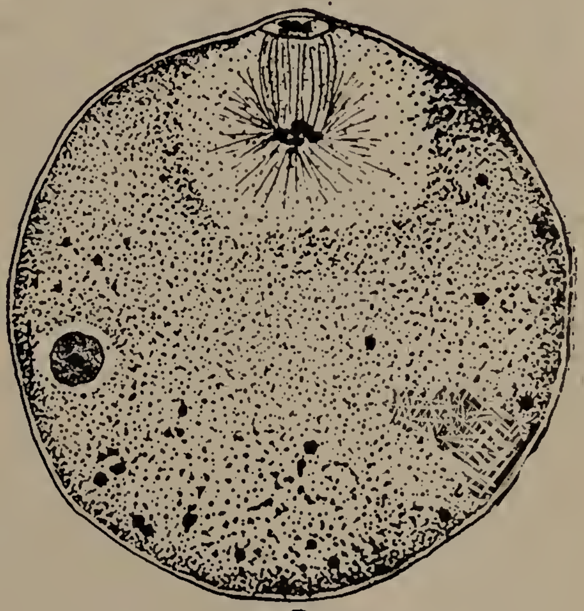
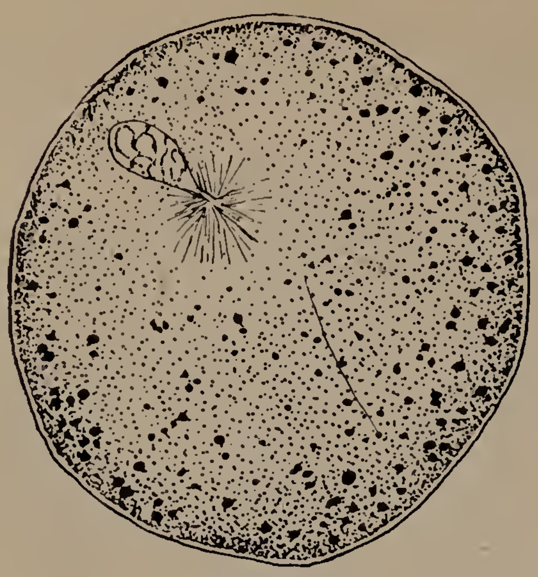


9.

8. Egg 5-6 minutes after fertilization showing spherical black sperm.

9. Egg showing change in sperm and the first polar body.



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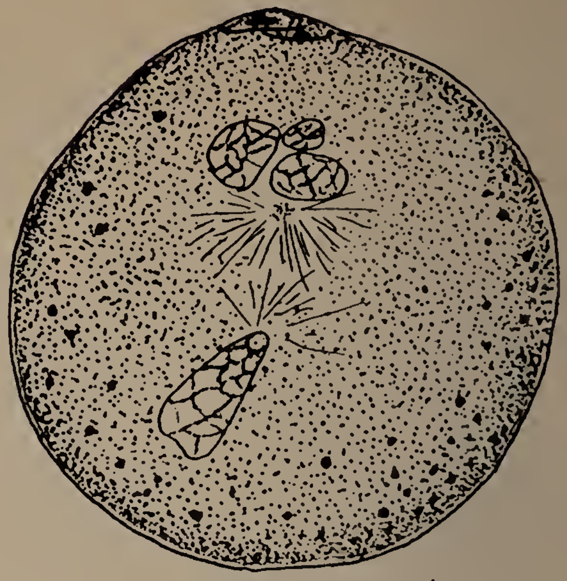

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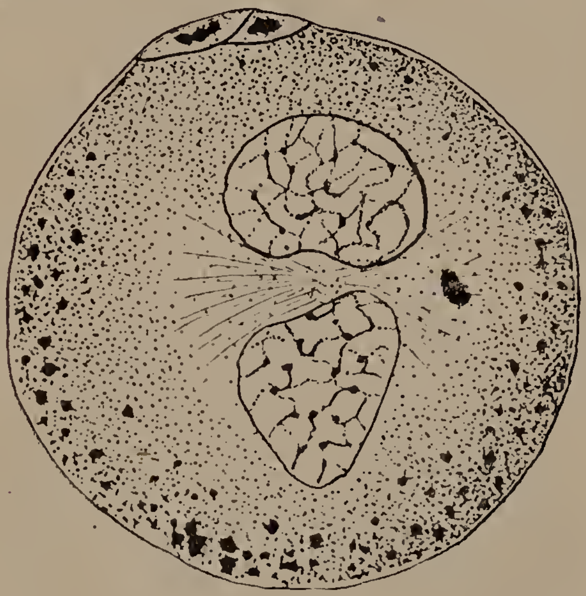
10. Shows male pronucleus and sperm aster.

11. Egg with chromosomal vesicles and arrow-head male pronucleus.



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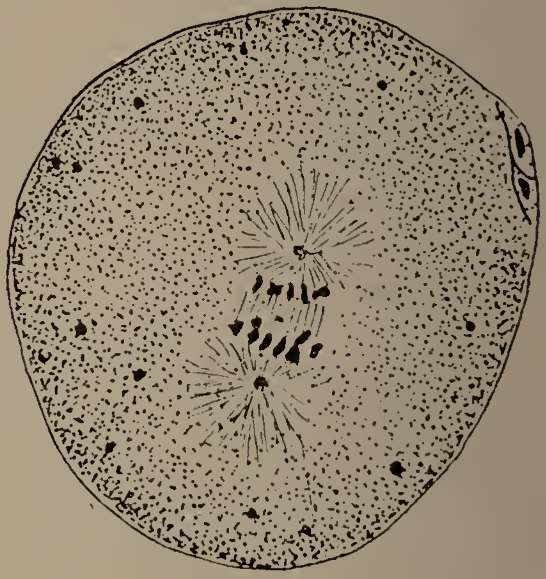
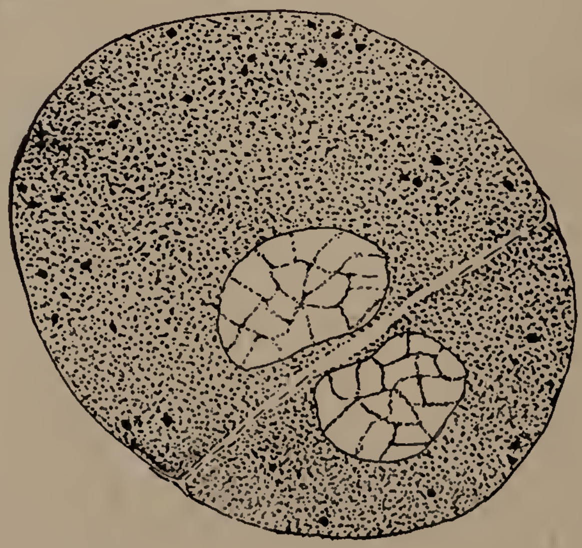


13

12. Shows two pronuclei before breaking down to form chromosomes for first divisional spindle.

13. Shows first divisional spindle.



14. Shows two celled stage.

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THE TECHNIQUE OF FRACTIONAL FERMENTATION.—BY PROFESSOR E. GORDON YOUNG, Ph.D., Department of Biochemistry, Dalhousie University, Halifax, N. S.

(Presented 14 February 1927)

The course of a bacillary fermentation is rarely if ever revealed by an analysis of the end products. Such end products are the result of countless generations of the organism, not as yet proved to be identical in their chemical activity. Moreover the chemical transformations of a single life span of the bacillus have likewise never been shown to be without change. The reason for this lack of knowledge of most species lies in the inadequacy of the technique. The apparatus described below was designed for such studies and arranged so that growth could be carried on either aerobically or anaerobically and samples of any volume withdrawn when desired for analysis. Figure 1 represents the arrangement.

The fermentation flask may be of any desired capacity. The author has been using 500 to 1000 cc. round bottomed pyrex flasks which must be blown specially as drawn. The flask is sterilised separately and filled with the various constituents of the medium and bacterial emulsions, or sowings, through the open arm. It is then placed in a thermostat at the desired temperature and connected up with the gas collecting apparatus chain as shown. The first collector is a specially blown gas wash bottle capable of containing 125 cc. of NaOH (5N) for the absorption of CO_2 gas. The lower part of this wash bottle contains a tap to allow the removal of small samples for analysis. The second collector is an aspirating bottle of a capacity equal to the expected gas production other than CO_2. The author uses a three litre volume for *B. coli communis* studies. This gas collector is filled with water and is connected to another of equal volume for displacement. A two way tap is inserted in the stopper of the first bottle for gas sampling purposes.

For removing samples from the fermentation mixture the free end of the flask, which is kept sterile, is attached to a sterile vessel of appropriate size. The fermentation fluid is withdrawn by suction and the fluid driven back by air or nitrogen as the case may be.

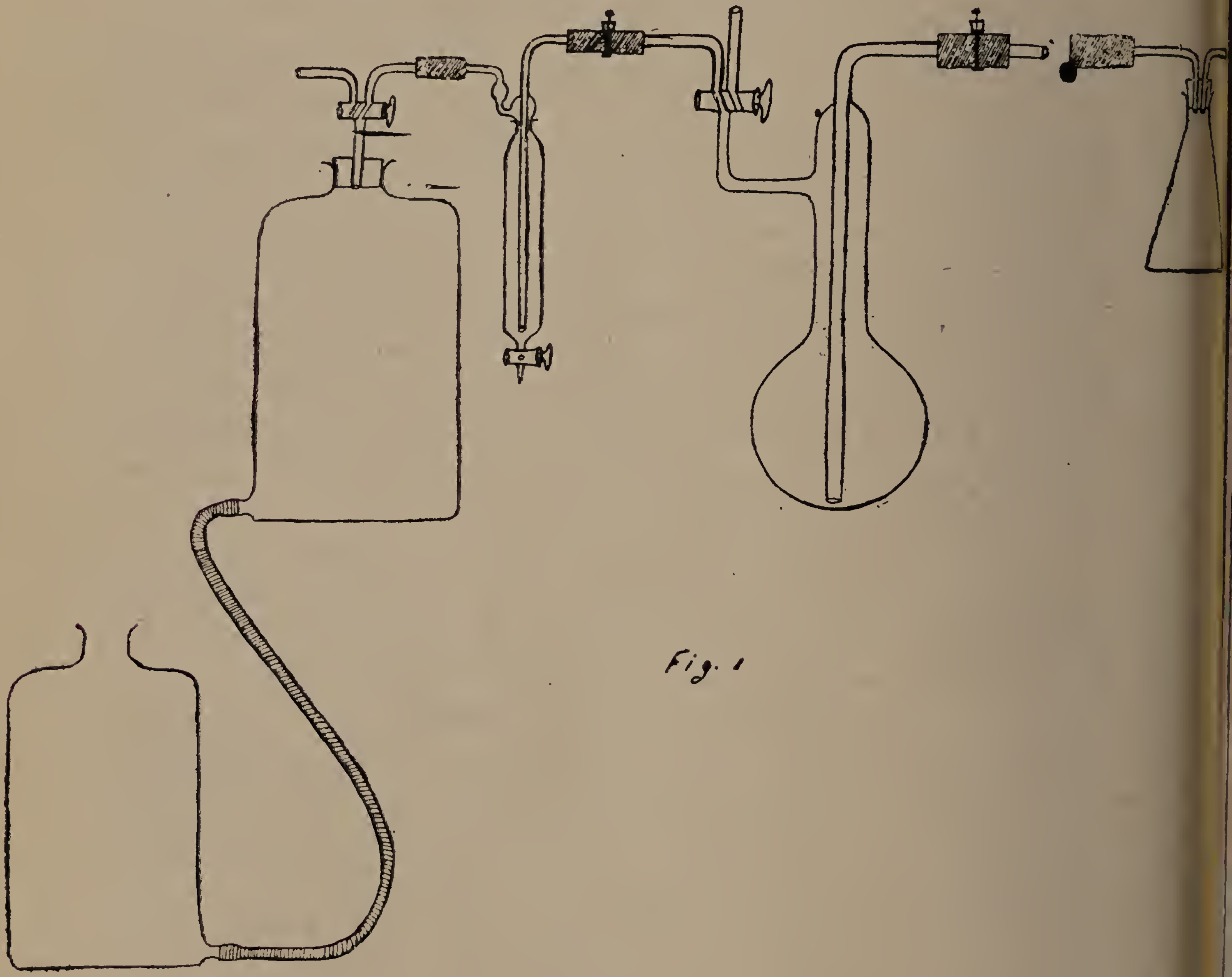

Fig. 1

A PANCREATIC BLADDER IN THE CAT, STRUCTURALLY ANALOGOUS TO GALL-BLADDER.

—BY R. J. BEAN, Laboratory of Histology & Embryology, and N. B. DREYER, Laboratory of Physiology, in the University of Dalhousie, Halifax, N. S.

(Presented 21 March 1927)

The pancreatic bladder described below was found in a cat, by a student, during a class experiment.

It lay to the right of the gall bladder and was of approximately the same size. The fundus was level with that of the gall bladder (fig. 1). Separating the fundi of the two sacs was a well-developed lobe of liver tissue.

Arising from the tip of this liver lobe a fold of peritoneum extended over the pancreatic bladder, eventually joining the peritoneal coverning of the gall bladder. This common fold extended from the middle of the sacs to the necks, and served to bring their walls into close contact. On removing the peritoneal layer the walls could be separated quite easily from one another above the free border of the peritoneum. The fundial portion of the pancreatic bladder, approximately 5 mm., showed no peritoneal investment. From the necks of the sacs the ducts are enveloped in a common fold of peritoneum.

The duct of the pancreatic bladder enters the pancreas at the level of the ampulla of Vater, 1 cm. to the right. The bile and pancreatic ducts followed their normal course. No accessory pancreatic tissue was found.

The colours presented by the pancreatic and gall bladders were entirely distinct; the former was white and the latter had the usual greenish-blue appearance. No communication existed between them. Bile could easily be squeezed out on pressure, but the pancreatic bladder remained quite firm, the only change observed was the distension of its duct. No connection with the pancreatic or bile duct or with the lumen of the duodenum could be made out.

As a matter of interest, it may be pointed out that seventeen hours after removal from the body the liver in the region of the gall bladder was stained green, while in the region of the pancreatic bladder no staining was present.

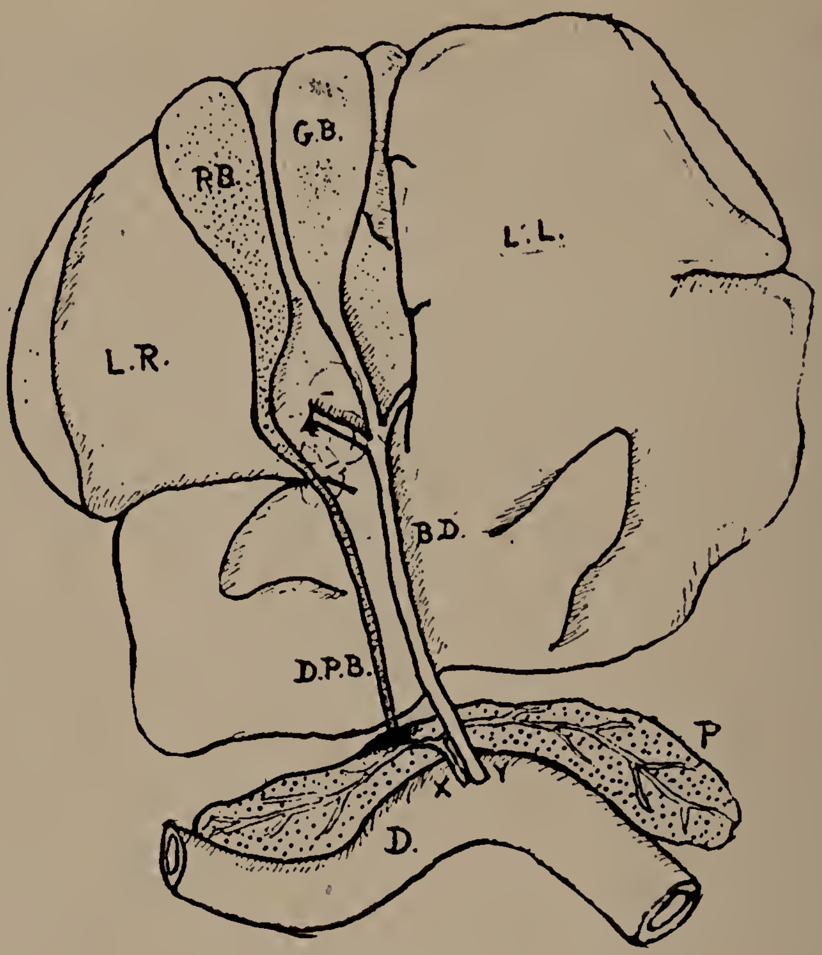

FIGURE I.

Semi-diagramatic figure of the gross anatomical relationships of the pancratic bladder P.B. BD., bile duct; D., duodenum; DPB., duct of the pancreatic bladder; GB., gall-bladder; LL., left lobe of the liver; LR., right lobe of the liver; P., pancreas; X., pancreatic duct; Y., ampulla of Vater. Note the indefinite termination of duct of the pancreatic bladder.

Histological Examination.

The liver, pancreas, and a section of the duodenum were placed in a 10% solution of formalin by the student who discovered the case. About 19 hours later the specimen was brought into the histological laboratory. After examination of the gross anatomical relationships, an incision was made in the side of the bladder, the fluid contents drawn off, and both the bladder and its duct were transferred to an acetic-alcohol mixture for two hours. The duct was then severed from the vesicle and each part was infiltrated with paraffin. Sections were cut 10 microns in thickness, and stained in haematoxylin and eosin for the preliminary examination. For purposes of differentiation, Van Giesen's stain and Wiegert's elastic tissue stain were used. Photomicrographs were made from iron-alum haematoxylin preparations.

The wall of the vesicle is made up of three distinct coats, an inner mucous, a middle muscular, and an outer fibrous tunic, Plate 1, fig. 2.

The mucous membrane is made up of a single layer of columnar epithelial cells resting on a vascular tunica propria. Sections cut from the wall of the bladder with a scalpel, cleared and mounted in balsam, show the mucous membrane in the form of a meshwork of tall rugose folds which intersect in such a way as to give it a honeycombed appearance, Plate 1, fig. 2. When viewed as a transverse microtome section, the intersections of the rugae are often seen as closed follicles, Plate 2, figs. 3 and 4. No goblet cells can be distinguished in the lining epithelium, nor is there any trace of either sub-mucous glands, or tubular crypts at the base of the rugae. The tunica propria consists of both white and elastic fibers, with stellate connective tissue cells scattered profusely throughout the fibrous matrix.

The middle coat is made up of dense bundles of smooth muscle fibers. The arrangement of these fibers varies in different parts of the vesicle. In some areas there are definitely three layers, an outer longitudinal, a middle circular, and an inner oblique which lies just beneath the tunica propria. In other portions of the vesicle, the three layers become blended in such a way that it is hard to distinguish a line of junction. In general, the circular and oblique fibers predominate. Ganglion cells are occasionally found along the boundary of the inner and outer muscle bundles.

The outer tunic is characterized by fibro-elastic tissue which is continuous with the peritoneal investment. This tunic, about one-third the thickness of the muscle layer, is further characterized by large blood vessels which course through its inner boundary giving off branches that supply the contractile and mucous membrane elements. Medullated nerves are also of common occurrence.

Unfortunately, the duct of the bladder sectioned poorly. A few crumbled mounts were made but a detailed histological study is impossible. As far as can be determined, the three coats of the vesicle are continued into its duct. The mucous membrane is apparently folded as in the case of the vesicle, but the connective tissue layer is relatively much thickened.

Discussion.

It must be admitted that the pancreatic bladder described above certainly resembles distended gall-bladder in structure. The clear cut structural differences between normal gall-bladder and pancreatic bladders as Boyden ('25) has pointed out, do not apply in the present case. Hypertrophy of the fibrous tunics which seems to be common in pancreatic bladders, is one of the characteristics of this case. However, the pattern of the mucous membrane suggests that the wall of this particular vesicle is not that of an hypertrophied pancreatic duct, as Boyden concludes from the cases he has studied. The uniform rugose mucosa, together with the absence of branched alveolar pits and sub-mucous glands, is more readily interpreted in terms of aberrant biliary tissue.

It is not the purpose of this paper to discuss in detail the theories which have been expressed on the origin of pancreatic bladders. Embryological evidence shows that the hepatic and pancreatic duct systems are derived from a localized area in the primitive gut. From the attempts to make a morphological analysis of this localization, Weber ('03), Ludwig ('19), Broman ('22), Bremer ('23), it appears that all degrees of abnormality, from cleft gall-bladder to a perfectly formed accessory pancreas, are theoretically possible. Bremer's theory of the "dual nature of the liver diverticulum, by which it is supposed to consist of liver-forming elements on its originally cranial half and of pancreas forming elements on its originally caudal half," would account for the development of the pancreatic bladder herein described. Boyden, who handled an immense amount of material in an effort to determine whether or not an intermediate stage between split gall-bladders and pancreatic bladders could be demonstrated, reports negative results.

Is it not possible that the case under discussion may represent such an intermediate stage?

PLATE I.

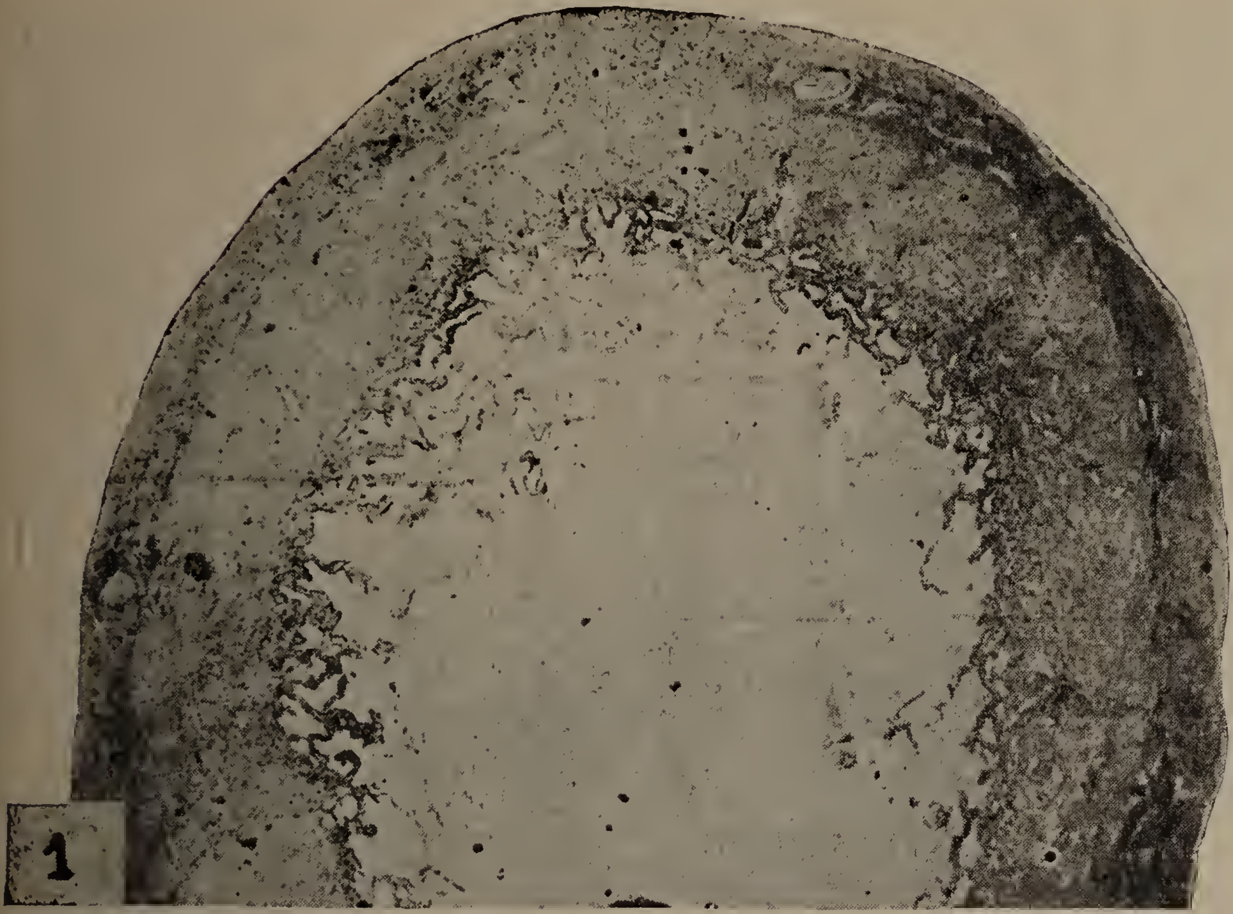

Fig. 1. Transverse section of the pancreatic bladder × 22. The fibrous outer tunic with its blood vessels forms a darker superficial covering for the middle muscular coat.

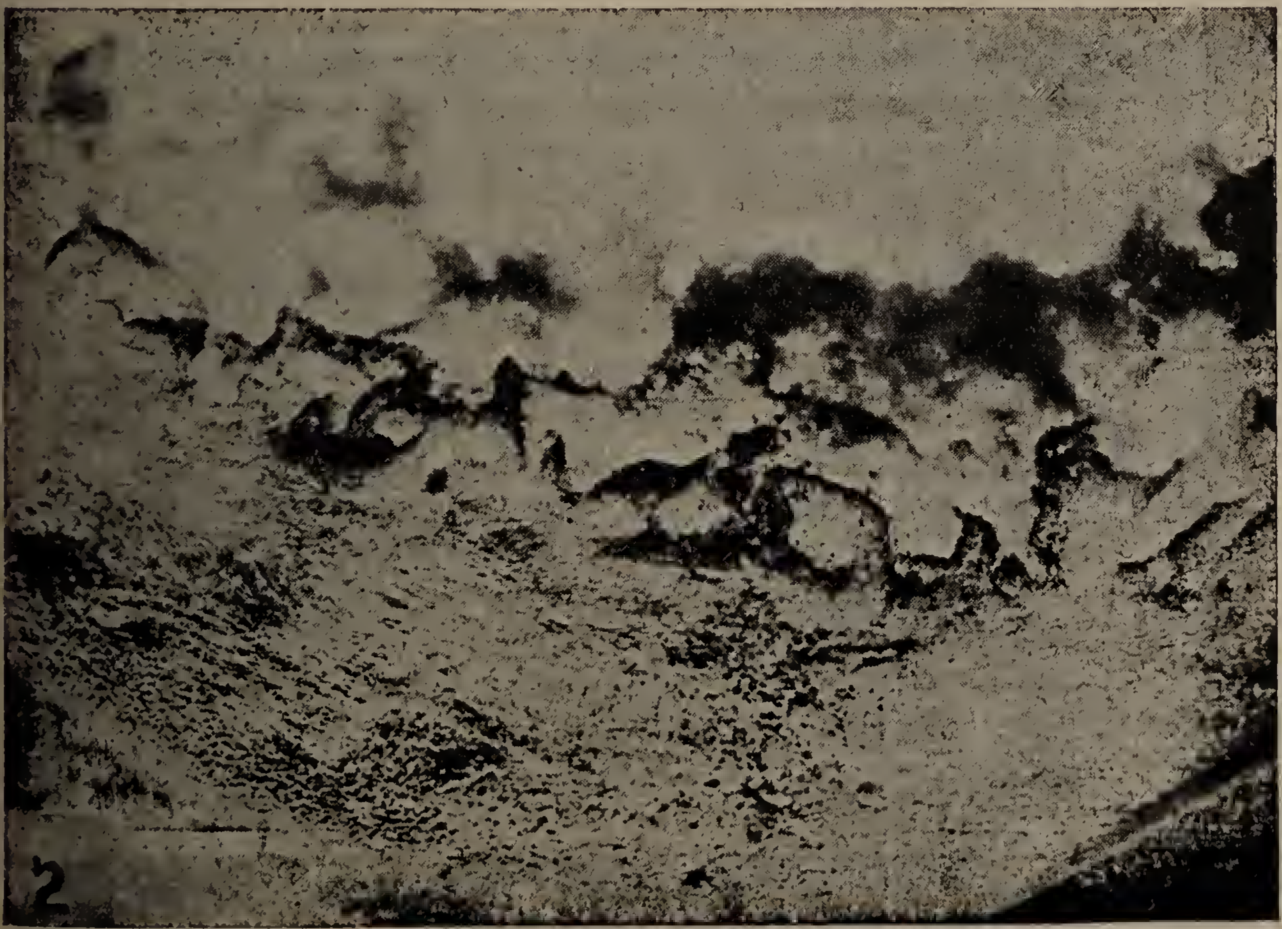

Fig. 2. Section of bladder cut away with a scalpel, cleared, and mounted in balsam, × 70. Note the honeycomb appearance.

PLATE II.

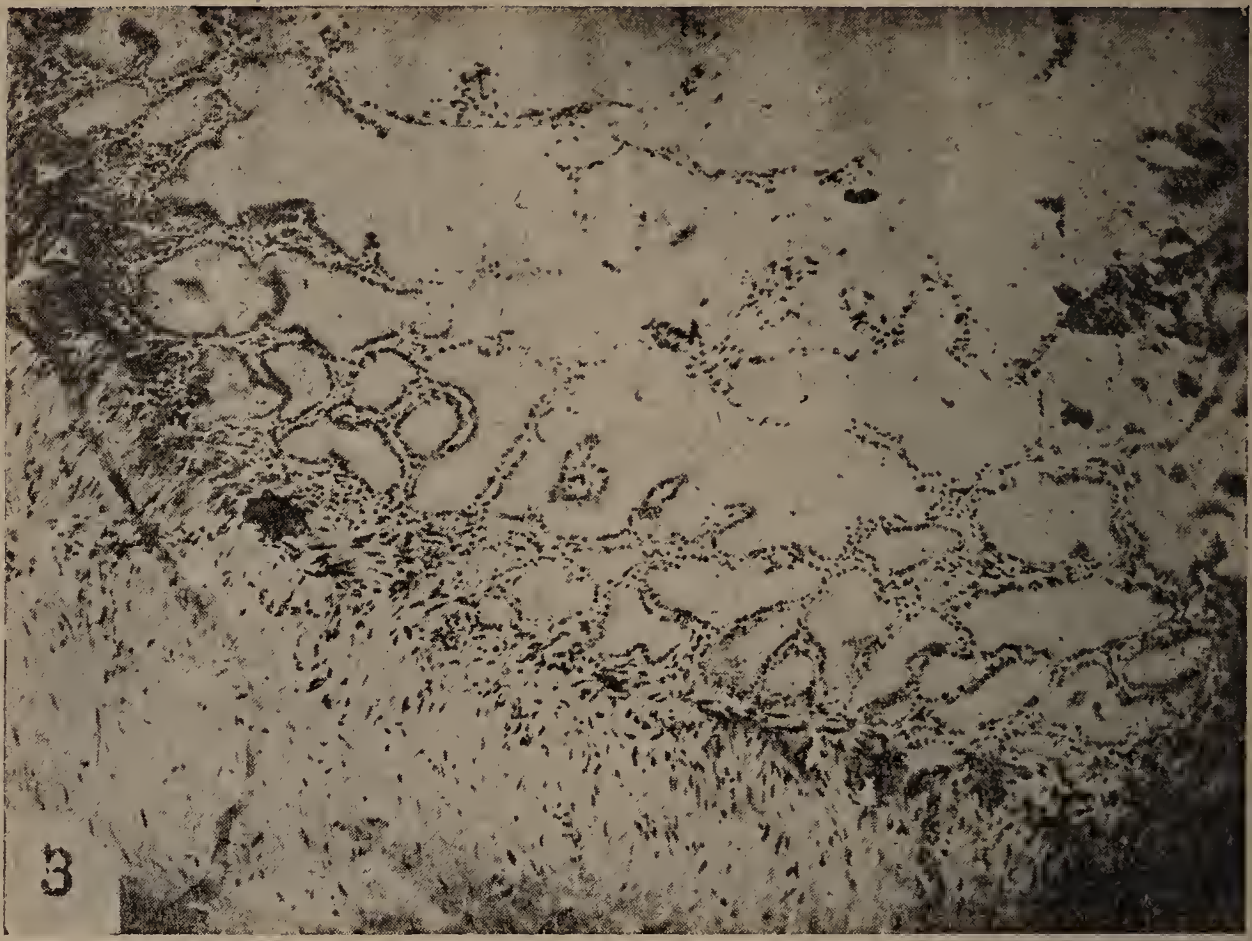

Fig. 3. Microtome section of the wall of the bladder, × 70. The intersections of the rugae appear as closed follicles. Note absence of tubular glands.

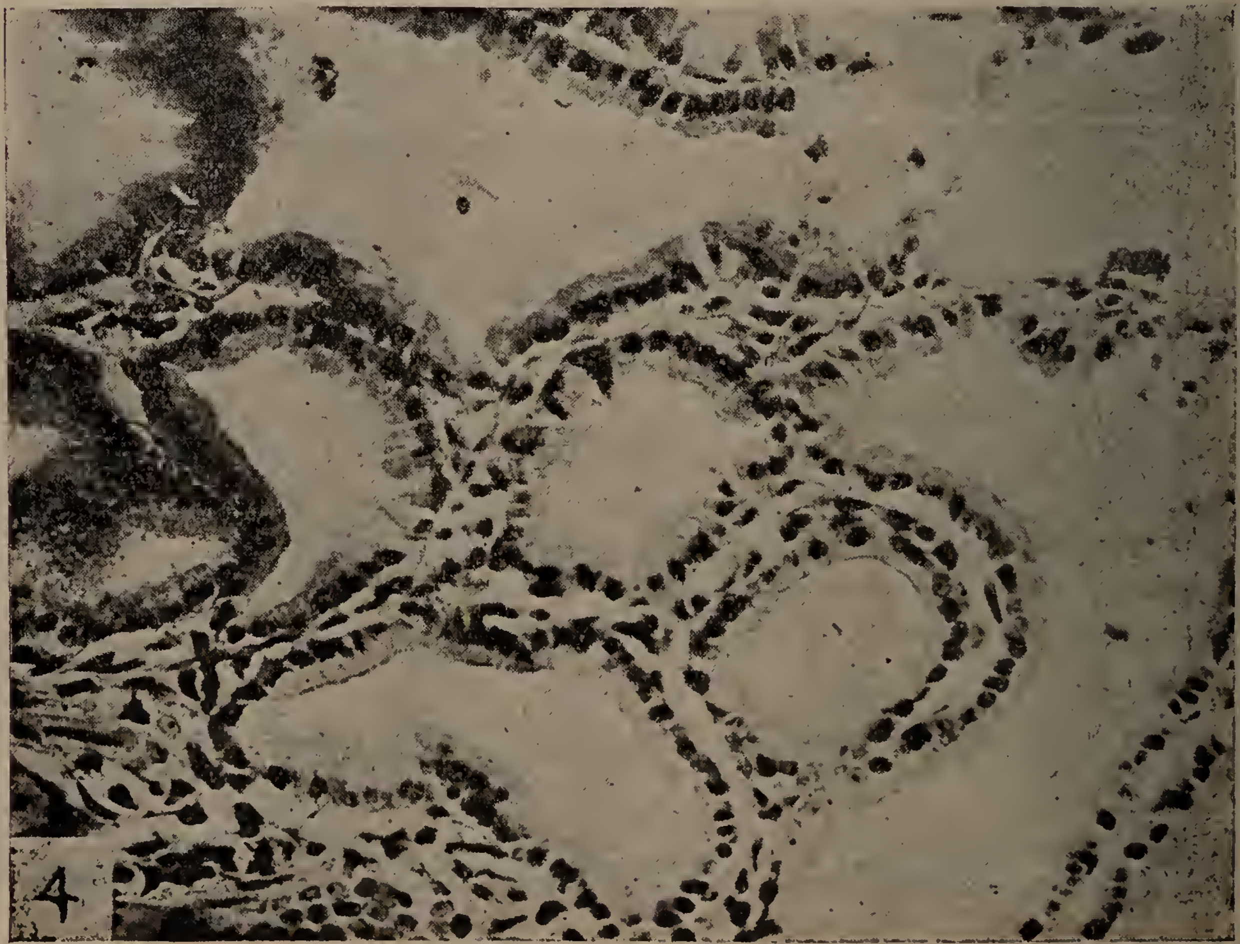

Fig. 4. Section of the mucous membrane taken from same field as in Fg. 3 × 275.

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CHEMICAL MANIPULATION. APPARATUS: GAS GENERATORS, MANOMETERS, ETC.—By DOUGLAS McINTOSH, M. A., D.Sc., Dalhousie University, Halifax, N. S.

(Presented 21 March 1927)

From time to time the student of chemistry employs some device or useful method of manipulation which he incorporates in a published article, where it frequently remains unnoticed, to be rediscovered by some other investigator. This could hardly occur if a description of his apparatus were given in a separate paper with a distinctive title. I am therefore describing a few pieces of apparatus which I have found convenient, and which I have used for a number of years. Some have been mentioned by me in various published papers; some doubtless have been used and described by others.

1. **Carbon dioxide generator.** A convenient substitute for the Kipp is a Dewar vessel with stopper and delivery tube, containing carbon dioxide snow. With the test-tube form which I ordinarily use, a "bag" of solid carbon dioxide (about 160 grams) gives a steady stream of gas for about 24 hours, while the same quantity in a litre flask lasts for nearly three days. The gas need not be washed or dried, for the vapour pressure of water at —78 degrees is only 0.01 mm. Since a 50 pound cylinder yields from 24 to 28 "bags", the cost of the material is about 30 cents.

It is, of course, much cheaper to use a reducing valve and the gas direct from the cylinder, since the yield of snow is only some 15 per cent.

2. **Apparatus for the Purification of nitrogen.** The commercial gas from a cylinder can be easily freed from oxygen by bubbling it through molten phosphorus in a modified Drexel flask kept at 100° in a water-bath. Professor F. M. G. Johnson and the writer found this an excellent method in some experiments where a small amount of the lower oxides of phosphorus was not harmful.

3. **Generator for acetylene.** The carbide is placed in a filter-flask and covered with alcohol. Water is added to the alcohol by a dropping funnel, and the acetylene is purified and dried by chromic and sulphuric acids, potassium hydroxide and phosphoric anhydride, and is finally solidified in a tube surrounded with carbon dioxide boiling under reduced pressure.

4. **Apparatus to show change of liquid to solid acetylene.** Acetylene under atmospheric pressure is a solid like carbon dioxide, but unlike the latter, it can be liquefied by a pressure of a few centimeters. If the liquid be placed in a test-tube closed by the finger, it solidifies instantly on opening the tube. This pretty experiment can be repeated several times with a small amount of acetylene.[1]

For continuous demonstration the apparatus shown in Figure 1 is satisfactory. The tube containing the solid acetylene is warmed with the hand until the acetylene is liquefied. On opening "A" the liquid solidifies. When the tube is placed in liquid air the gas passes from the large bulb to the tube. Stop-cock "A" is then closed, and the tube is warmed again until liquefaction is complete. The experiment can then be repeated without loss of gas.

5. **Platinum resistance thermometers.** A platinum wire thermometer wound on glass has certain advantages over the ordinary form utilizing a mica frame. Dr. Barnes and the writer made a large number of these of a special pattern for boiling-point determinations, and several in which glass rods or closed tubes were used were made at the same time.[2] Since these have been recently described as something new, an account of the way in which the glass spiral was made may not be out of place.

The tool for ruling the spirals was made from a hollow piece of brass holding a light spring. The cutting edge was kept by the spring from pressing too strongly on the glass. The tube or rod was coated with wax, centered in the lathe, and a double spiral cut in the wax. The spiral was then deeply etched with hydrofluoric acid solution. The resistance wire

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[1] This was shown to me by Mr. E. Lesueur of Ottawa.

[2] Phil. Mag. 350, 1903.

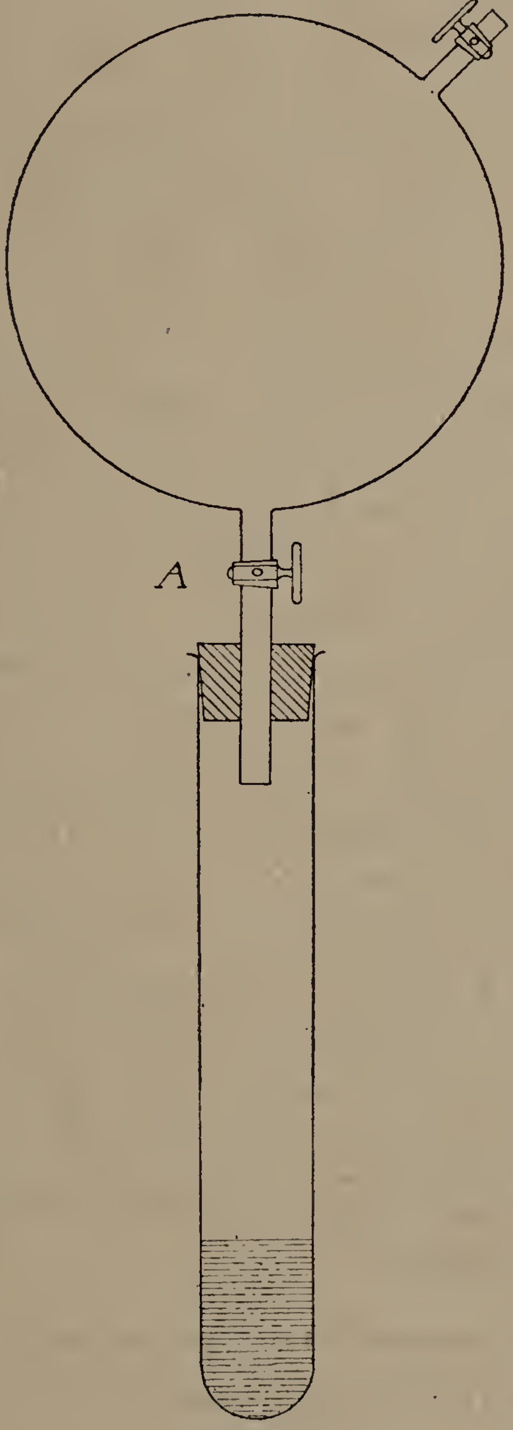

FIG. I

is doubled and the loop attached at the lower end of the spiral by a drop of molten glass, wound in the depression, fastened at the upper end, and fused to the copper leads. The compensation leads are fixed in place, and the whole enclosed in a tightly fitting glass tube. A thermometer made in this way in 1903 is still in constant use.

6. **Manometers.** For pressures to one atmosphere the ordinary U shaped form (Figure II) is quite satisfactory. These can best be filled by exhausting and then distilling in the mercury. If made in this way the mercury remains clean; while, if filled with mercury and the air removed by boiling, a scum is often noticed on the surface. Professor Maass and I called attention to the advantage of filling manometers in this way in 1914.[1]

Pressures of from one to five or six atmospheres can be conveniently measured with an air or nitrogen filled manometer. The upper part of the manometer is graduated and carefully calibrated, and is then sealed to the U tube. After drying and exhausting, the gas is admitted and the proper amount of mercury distilled or poured in. If the high pressure manometer be now sealed to the low pressure one at "B", it can be calibrated while the low pressures are being measured. To prevent the mercury of the high pressure gauge from being drawn over at the low pressures, it is frozen by means of carbon di-oxide snow at the bend.

The calibrated part of the manometer is kept at constant temperature by means of an outer tube, through which water circulates, or by an ice-bath. In the latter case a basket of fine mesh, fitting the outer tube closely, is used. When a reading is to be made the basket is raised, and the gauge is easily read through the ice-water surrounding it. The diagram makes the method clear.

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[1] Trans. Royal Soc. Canada, 8, 66.

A neat device for the manometer of a hydrogen thermometer is shown in Figure II. If any gas enters the tube it may be pushed up to the reservoir at the top and trapped. Dr. B. D. Steele showed me this apparatus many years ago. I mention it since it has been "rediscovered" recently.

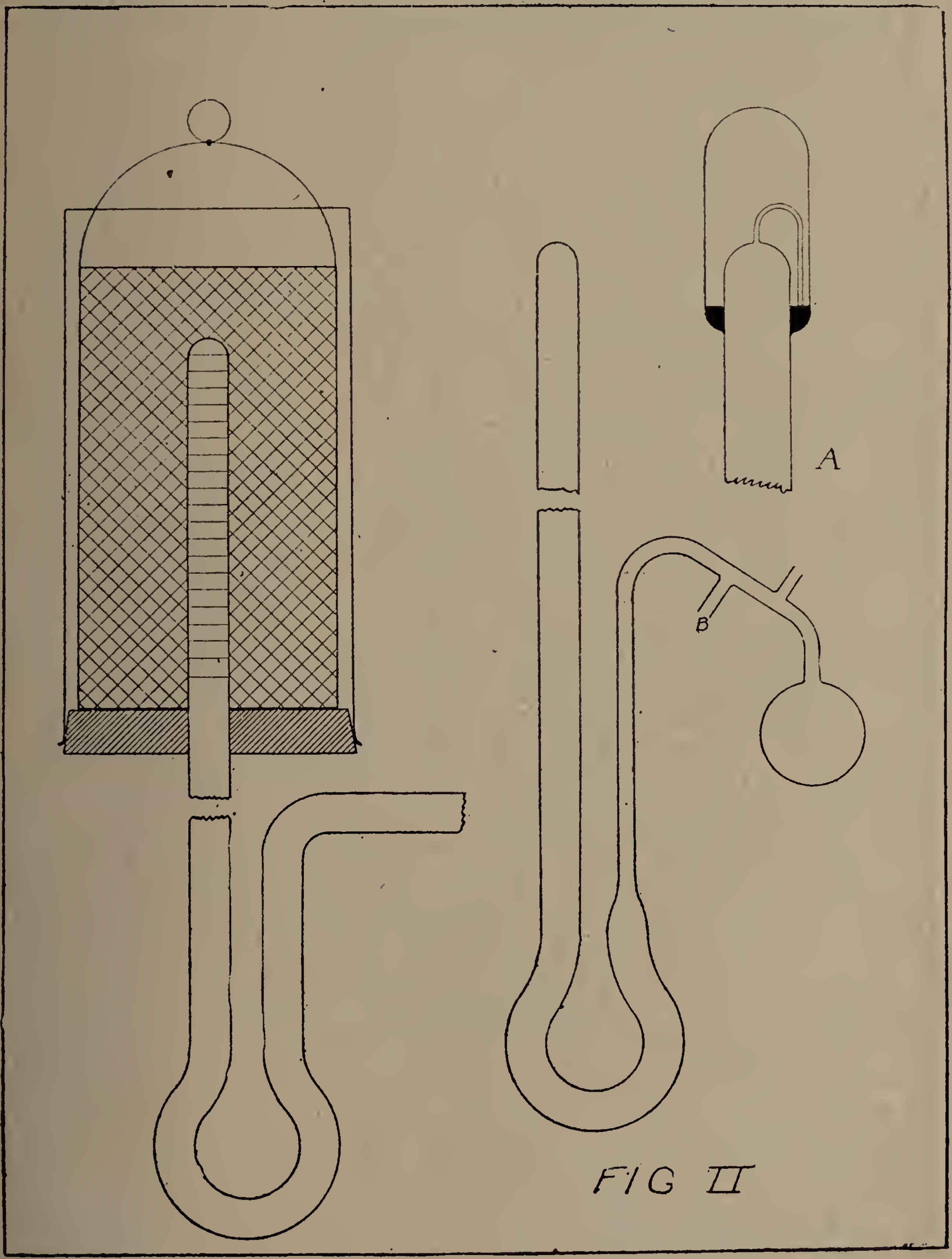


FIG II

7. **Bell for delivering gases.** Figure III makes the principle clear. The bell is allowed to fill up slowly from a generator. When the gas reaches the level of the side tube it siphons out quickly. It is an easy matter to arrange this apparatus, so that the gas may be measured with some accuracy. I have no doubt that this has been used before, although I have never seen it, nor had Dr. Maass of McGill.

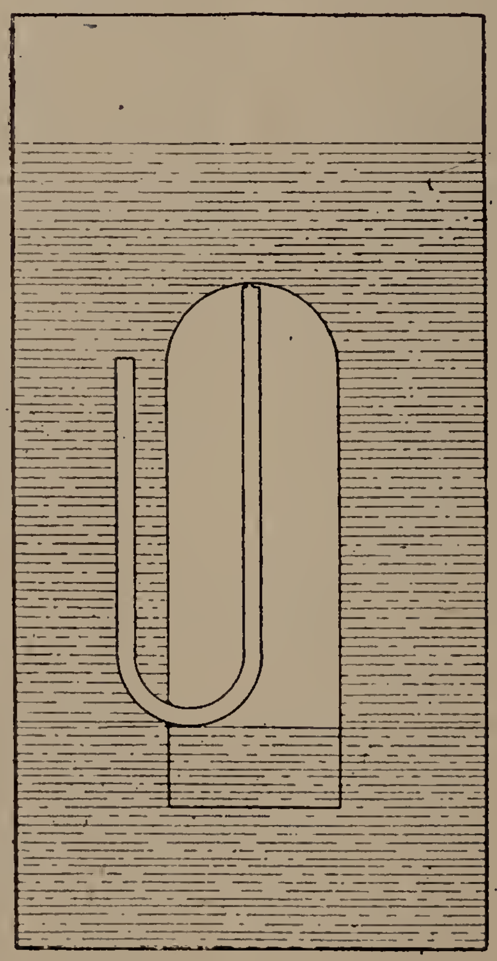


FIG. III

8. **An automatic siphon.** This differs from the ordinary form only in having the tube "A" (Figure IV) which admits the air, bent so that it is only a short distance above the level of the out flow tube. When the liquid to be transferred rises to "B" admission of air is stopped and the siphon runs quickly. The level of the liquid can be kept between "A" and "B".

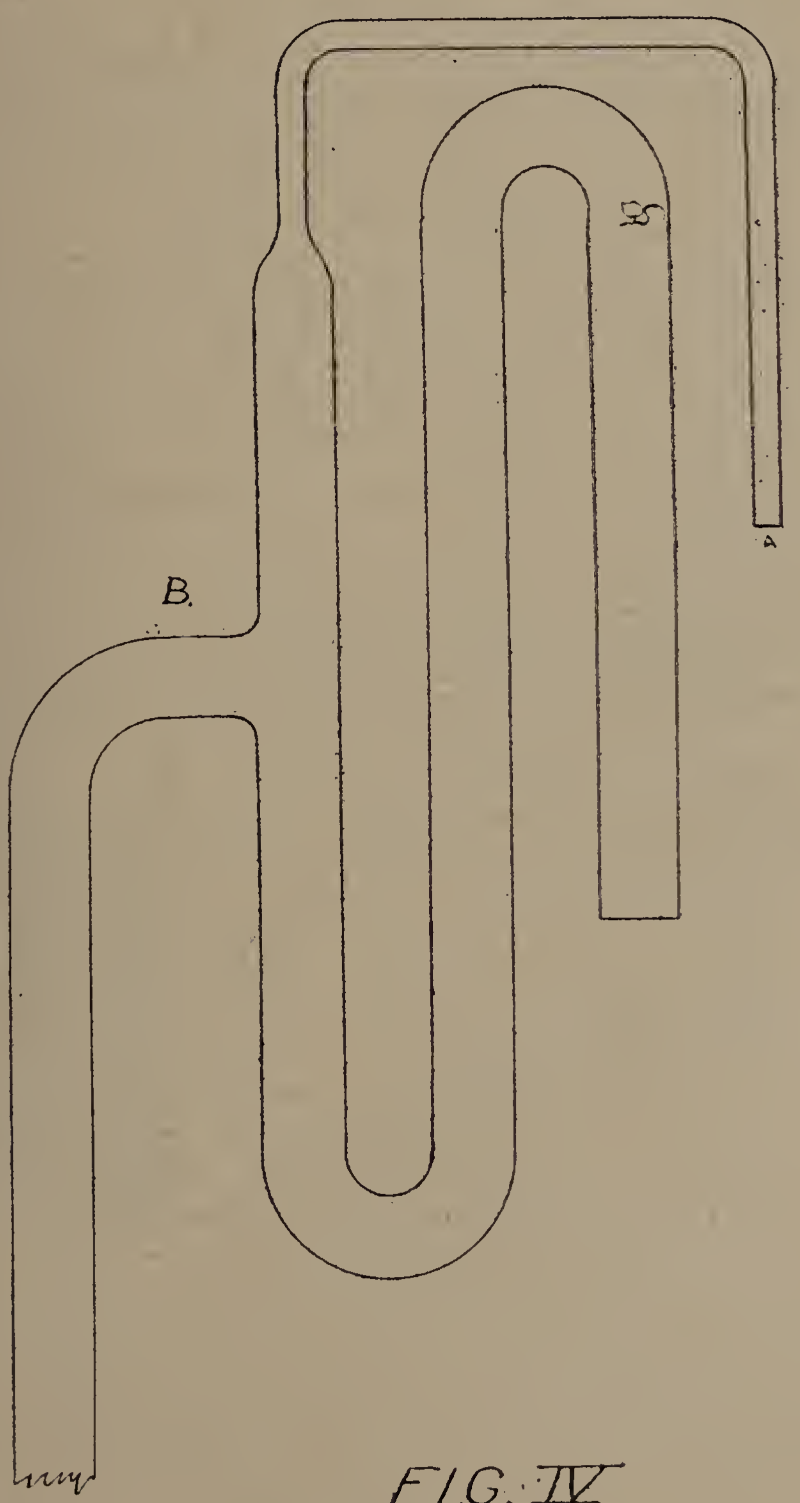


FIG. IV

9. **A device to regulate the swing of an analytical balance.** The diagram Fig. V, shows this simple arrangement. On pressing the rubber bulb a gentle current of air impinges on the bottom of the pan, making the balance swing through a few divisions. If on releasing the support the pointer moves over too large an arc, the swing may be easily damped by the air current.

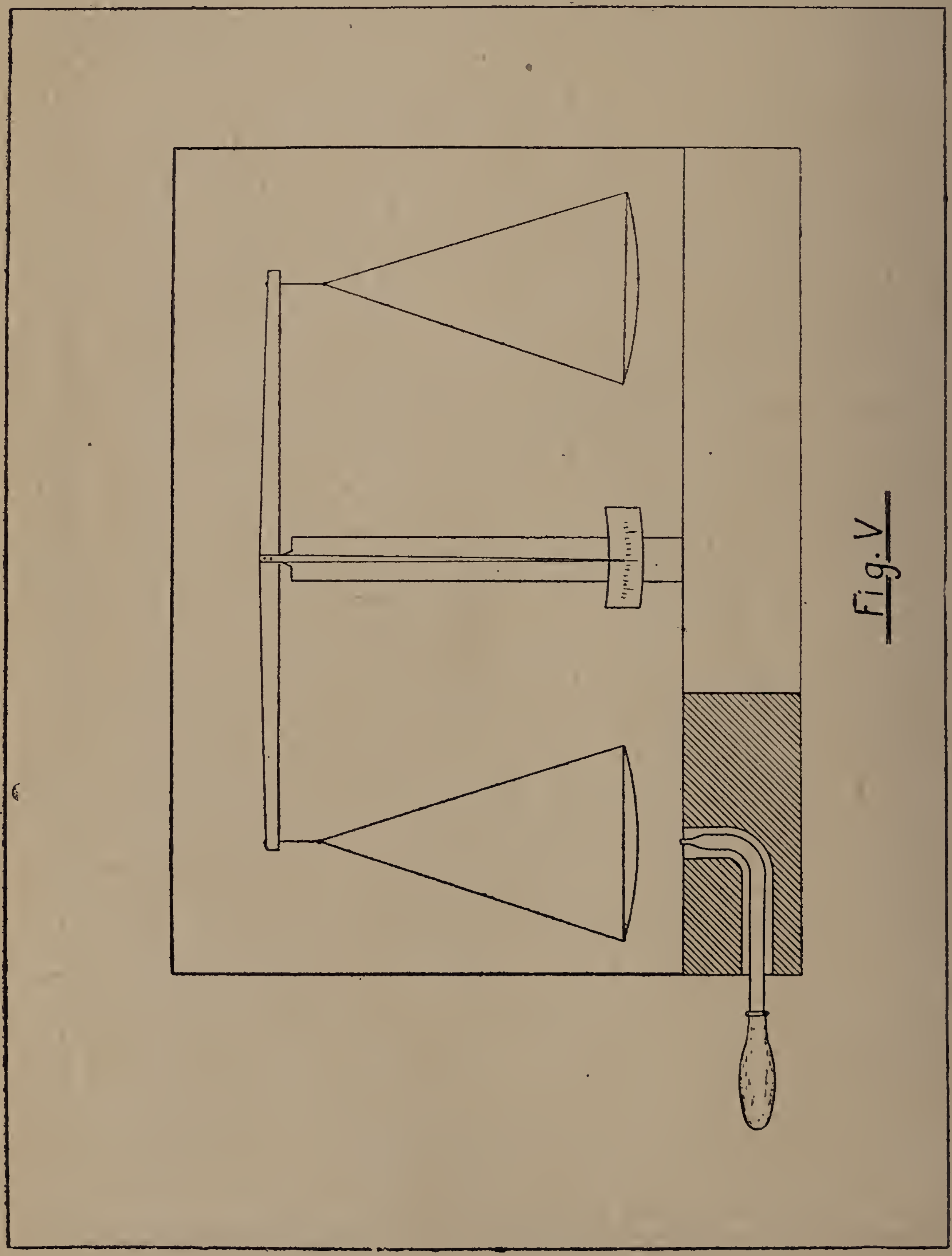


Fig. V

The Autolytic Power of Bacillus coli communis.—By Prof. E. G. Young, Ph. D., Department of Biochemistry, Dalhousie University, Halifax, N. S.

(Presented April 11 1927)

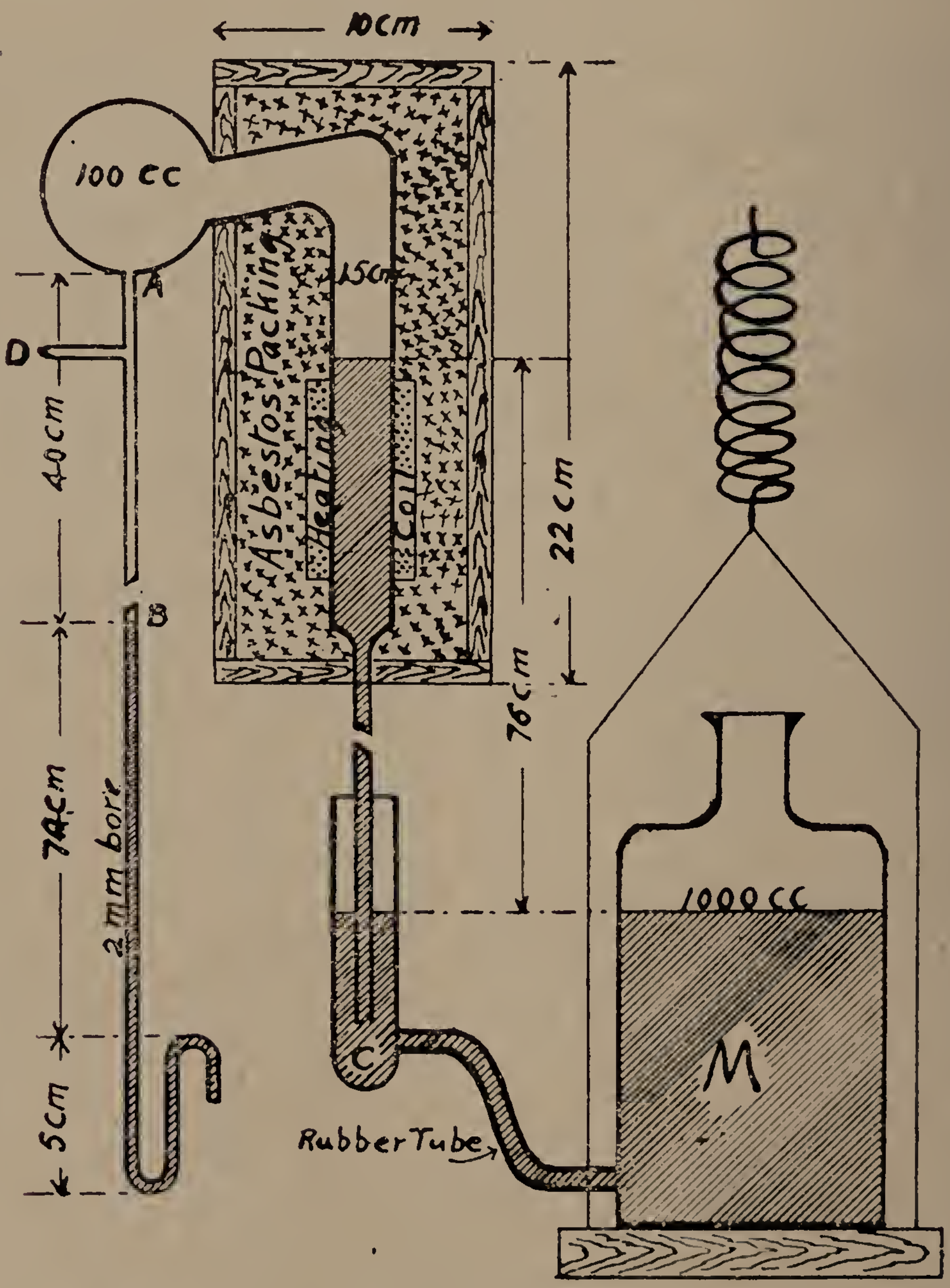
Highly concentrated emulsions of *B. coli communis* were prepared in saline from growths on nutrient agar. They were then frozen and thawed repeatedly, using a freezing mixture of solid carbon dioxide and ether, until the medium was sterile or nearly so. The resulting medium was passed through a a Berkefeld filter, then added to a solution containing glucose, peptone and appropriate salt mixture. This medium was placed in a theromostat at 37° C. for several weeks in the presence of nitrogen gas and analysed at frequent intervals. This technique reveals that *B. coli communis* has no autolytic power to decompose glucose. Hydrolysis of peptone proceeds very slowly at pH 6 to 8 as shown by an increase in the number of free amino groupings

A SIMPLE AUTOMATIC MERCURY STILL.—BY HOWARD L. BRONSON, PH. D., Professor of Physics, Dalhousie University, Halifax, N. S.

(Presented 21 March 1927)

Mercury stills of various types and many designs are widely used in university and commercial research laboratories. In fact, there is scarcely a laboratory so small that it does not feel the need of some such device for purifying mercury, but most of those at present in use either require too much attention or withdraw too much mercury from circulation.

The accompanying figure illustrates a still that possesses certain very definite merits.



(1) The mercury container M is supported by a spring of such length and stiffness that the mercury level in C is practically independent of the quantity of mercury in M. As far as the writer is aware, this is a new device which enables the still to operate continuously and without attention for as long as three or four days. If desired, the heating circuit can easily be arranged so that it will be opened automatically by the fall of the mercury level in C, in case the container M. becomes empty.

(2) The tube AB is made of such length and size that it acts as a Sprengel pump and thus insures a permanent high vacuum above the mercury and consequently a low boiling point.

(3) The volume of mercury permanently tied up in the still is only about 50cc and this could readily be reduced to 20cc by the use of still smaller apparatus.

(4) It can be easily and quickly made in any laboratory at a very small expense and the cost of operation is trifling.

The following details in addition to those furnished in the figure may be found helpful in constructing such a still:

Pyrex glass was used throughout and the heating coil wound directly on it. The latter was made of about 45 feet of No. 26 oxidized "Ideal" wire having about 1.2 ohms per foot. The E. M. F. supply was taken from a small homemade transformer giving about 37 volts on the secondary. An ordinary "heavy duty" bell-ringing transformer would be quite suitable for the purpose. A fairly low voltage is desirable for much greater care would have to be taken with the insulation if the still was to be operated directly off a 110-volt lighting circuit. The power consumption in the above heating coil is about 25 watts and about 110 grams of mercury is distilled per hour. The still was originally exhausted through the side tube D by means of a common air pump.

The fact that the efficiency of the process is only about 40% is a minor consideration when the total power consumed is so small. However, it could undoubtedly be considerably increased by taking sufficiently great care with the asbestos packing.

THE HEAT CAPACITIES OF ACETALDEHYDE AND PARALDEHYDE, AND THE HEAT OF TRANSFORMATION OF ACETALDEHYDE INTO PARALDEHYDE.—BY D. LEB. COOPER, B. SC., Department of Chemistry, Dalhousie University, Halifax, N. S.

(Presented 6 May 1927)

In 1865 Kekule and Zincke (A. 162, 125-1865) noticed the fact that acetaldehyde under the influence of a number of catalysts polymerized into two products, the nature of the polymerization depending upon the temperature at which the reaction took place. Above O° C. acetaldehyde changed into paraldehyde, and below that temperature to metaldehyde, both of the polymers having the same empirical formula but different structural formulae. Fehling (Ann. 27, 319) noticed that during the conversion to paraldehyde there was a large heat change. The work of Turbaba (Zeit. Phy. Chem. 38, 505.—1901) established the fact that the point of equilibrium is independent of the catalyst used, and gave at the same time measurements of the rate of reaction under the influence of various catalysts, deduced from measurements of volume change, and density measurements. By volume change he found the equilibrium at 50.5°C to be 33.36-35.23 per cent acetaldehyde, by density measurements 33.87 per cent acetaldehyde and 66.13 per cent paraldehyde. The speed of the reaction varied greatly with the catalyst used, but in the case of acids was roughly proportional to the concentration of the hydrogen ion. Roozeboom(Prec. K. Akad. Wetensch, Amsterdam.) found at 41.7°C. (the Natural Boiling Point of the equilibrium mixture) the equilibrium to be 53.7 mols per cent. paraldehyde, and at 6.8°C. (Natural Freezing Point) 88.1 mols per cent. Holleman (Zeit. Phy. Chem. 43, 129.—1903) gives the following numbers for the natural points and the equilibrium at those points;

88.3 mols percent	paraldehyde at	6.75°C.
53.4 mols percent	"	41.6° C.

According to Hess' Law the heat of change should be positive and equal to the difference between the heats of combustion of the two substances. Berthelot and Delepine (Compt. rend. 130.—1900) found the heat of combustion of acetaldehyde to be 297,150 cals. per mol. Louginine's figure for paraldehyde is 813,200 cals. per mol. From Hess' Law the heat of change should therefore be

$$838500—813200 = 25300 \text{ cals.}$$

The method for the determination of the heat of change described elsewhere required the specific heat of paraldehyde and acetaldehyde over the range 16°-18°C. The work was extended to include the range -78.5°C. to 100°C. for paraldehyde, and -182.5°C. to 17°C. for acetaldehyde. The latent heats of fusion were determined directly from the heat capacity curves.

Apparatus and Manipulation.

The ordinary form of a Richard's Adiabatic calorimeter was used, adapted to the needs of the experiment by having inserted in a removable top to the outer container a tube of diam. 2 cm., and sufficiently long to extend well above the surface of the water in the outer vessel of the calorimeter. A Beckmann thermometer compared as well as possible against a mercury thermometer standardized by the Reichanstalt was inserted in the outer bath. The difference in temperature between the calorimeter proper and the outer bath could be read to .0003°C., and kept constant to .0006°C. after the large primary heat change was completed.

Neglecting small errors the error of the method depended almost entirely on the accuracy with which the change in temperature of the inner calorimeter and its contents could be read. An average change in temperature was .500°C., deviation .005°C. The approximate heat capacity of the substance and container for this change in temperature was 2000 cals., for the glass container alone 400 cals. The approximate maximum error in the final result would therefore be one per cent.

After unsuccessful attempts to use brass, and ordinary glass vessels, as containers for the liquids, the materials were sealed in thin walled Pyrex glass vessels which had been thoroughly cleaned by treatment in the usual manner with steam, and thoroughly dried. At the end of the determinations the melting point of the paraldehyde remained unchanged. The acetaldehyde showed some traces of resins which may have been caused by slight traces of impurities in the glass.

The Container was allowed to remain in the constant temperature bath kept at the desired temperature for one hour, and in the calorimeter for 8 minutes after any detectable heat change had ceased. The transfer from the constant temperature bath to the calorimeter could be accomplished very quickly, so no appreciable error was introduced. The adequacy of the time of cooling and the time the container was allowed to remain in the calorimeter was proven by two measurements; 1. a measurement of the time of cooling of paraldehyde to -78.5, and 2. a measurement of the time elapsing, between the entry of the cooled container and its contents in a constant temperature bath, By measurement number two it was also shown that packing the container with copper gauze offered no advantage.

Purification of Materials.

Paraldehyde—Commercial paraldehyde was distilled, and the fraction between 123°-124° collected for the preparation of the pure paraldehyde. The melting point of this fraction varied between 10° and 11°C. in different runs. The material thus obtained was refluxed over sodium for two hours and again distilled from over the sodium and collected in well cleaned Pyrex flasks. The effect of the sodium is to remove any traces of water in the paraldehyde, and to resinify any acetaldehyde remaining from the former distillation. The melting point of this material was 12.30°C. By fractional crystallizing this material the melting point after four such crystalizations rose to 12.50°C. and there remained constant. It was assumed that paraldehyde with this melting point was pure. Following are some of the melting points ascribed to pure paraldehyde;

Holleman	12.55°
Turbaba	12.61°-12.58°
Lieben	12.00°

The pure paraldehyde was kept in Pyrex flasks closed with a well waxed cork stopper. At the end of three months the melt-point remained unchanged.

Acetaldehyde.

The fraction of paraldehyde distilling between 123°-124°C. was placed in a distilling flask fastened to a spiral condenser. The condenser had at the other end a reverse adapter cooled by a freezing mixture of ice and salt. A few drops of 50% sulphuric acid was added to the paraldehyde and on gentle heating the mixture boiled (41.8°C) and acetaldehyde distilled over. Direct distillation of the mixture according to Holleman (ibid) gives a mixture containing 1.5 mols per cent of paraldehyde, which condenses in the reverse adapted used. The freezing point of the liquid thus obtained was not tested, and since some doubts concerning the purity of the liquid arouse later it is the intention of the author to try another method of purification, and repeat the measurements with a new lot of acetaldehyde. The freezing point of acetaldehyde is given by Holleman as -118.0°C. and by M. Chavanne as -123.45°C.

Experimental Results.

Paraldehyde and Acetaldehyde.—Table 1 represents the experimental data on paraldehyde, table 2 that on acetaldehyde. Column 1 gives the temperature of the constant temperature bath, and column two the mean heat capacity per gram from that temperature to 17.0°C. The heat capacity per gram of Pyrex glass corrected to 17.0°C. is given in table No. 3.

TABLE NO 1.

Paraldehyde.

1.	2.
–78.5°	51.35
–46.0°	43.18
– 0.0°	30.70
– 0.0°	7.575
50.0°	13.89
100.0°	33.41

S = super cooled liquid

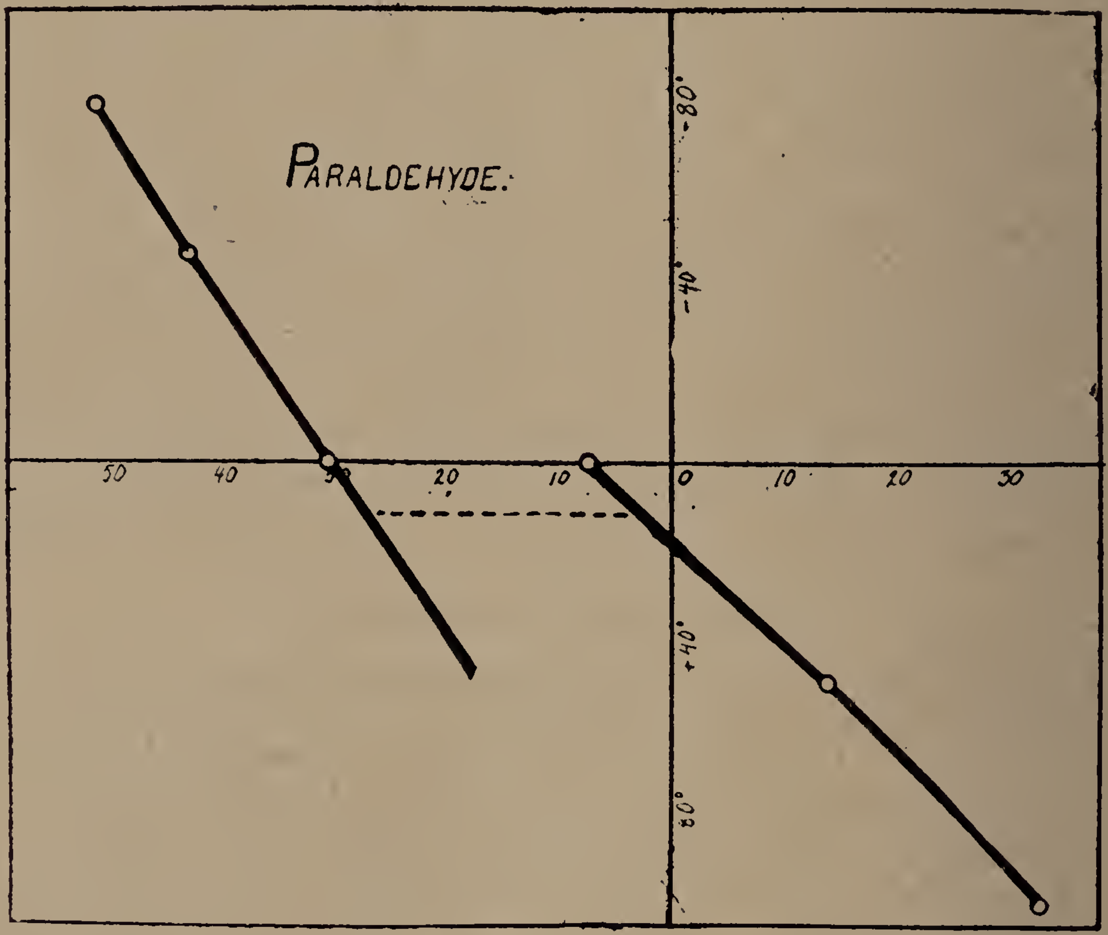
TABLE NO. 2.

Acetaldehyde.

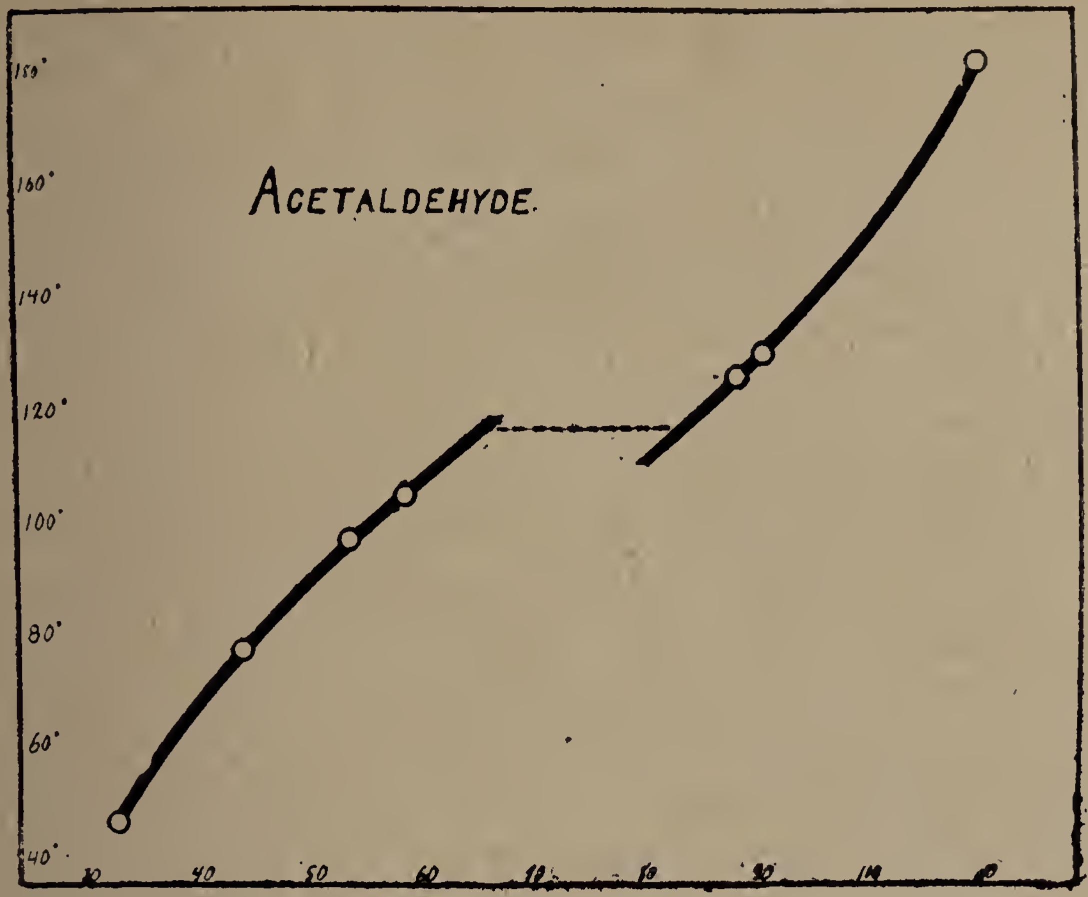
1	2
–182.5°	109.45
–131.0°	90.0
–127.4°	87.9
–106.5°	58.0
– 98.5°	53.3
–78.5°	43.90
–47.0°	32.7

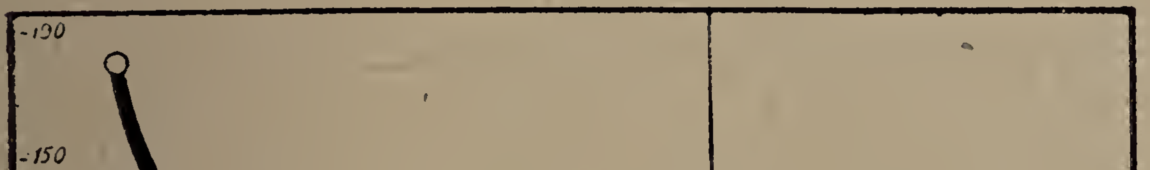
TABLE NO. 3.

1.	2.
-182.5°	23.86
-127.4°	21.30
-98.5°	18.07
-78.5°	15.69
-50.0°	11.30
-46.0°	10.83
100.0°	15.13



The heat capacities of the paraldehyde and acetaldehyde were plotted and the curves shown obtained. From the curves the latent heats of fusion are; for paraldehyde 25.2 cals, for acetaldehyde 17.6 cals per gram at M.P. -118°C. Louginine and Dupont (Bl. Soc. Chim. 4, 9, 223.) give 25.02 for the latent of fusion of paraldehyde.


ACETALDEHYDE.
180°
160°
140°
120°
100°
80°
60°
40°
30
40
50
60
70
80
90
110
0


PYREX GLASS.
-190
-150
-110
-70
-30
+10
.50
+90
25
20
15
10
5
0
5
10
15

The Determination of The Heat of Change.

Evperimental Method.—Paraldehyde of B. P. 123° was distilled as described elsewhere, and the acetaldehyde thus obtained, containing 1.5 mols per cent of paraldehyde was placed in a glass vessel closed at one end and drawn out to a narrow tube at the other. A small inner tube containing sulphuric acid 50% and so constructed that when in the vessel containing the acetaldehyde the surface of the tube extended well above the surface of the aldehyde, was dropped through the opening in the container. The acid was thus prevented from reaching the aldehyde till it was desired that the reaction should proceed. The tube was sealed in such a manner that a thread could be attached to both ends. It was allowed to remain suspended in the calorimeter in an upright position till its contents had assumed the same temperature as the contents of the calorimeter and a reading of the Beckmann thermometer taken. The container was then inverted without removing it from the water of the calorimeter by drawing on the thread attatched to its bottom, thus allowing the acid in the small enclosed tube to reach the acetaldehyde. The reaction proceeded almost immediately. Readings were taken at suitable intervals till three successive readings were the same within the error of reading the thermometer. After the apparent finish of the reaction the container was righted and inverted several times to make certain that all the material had reacted.

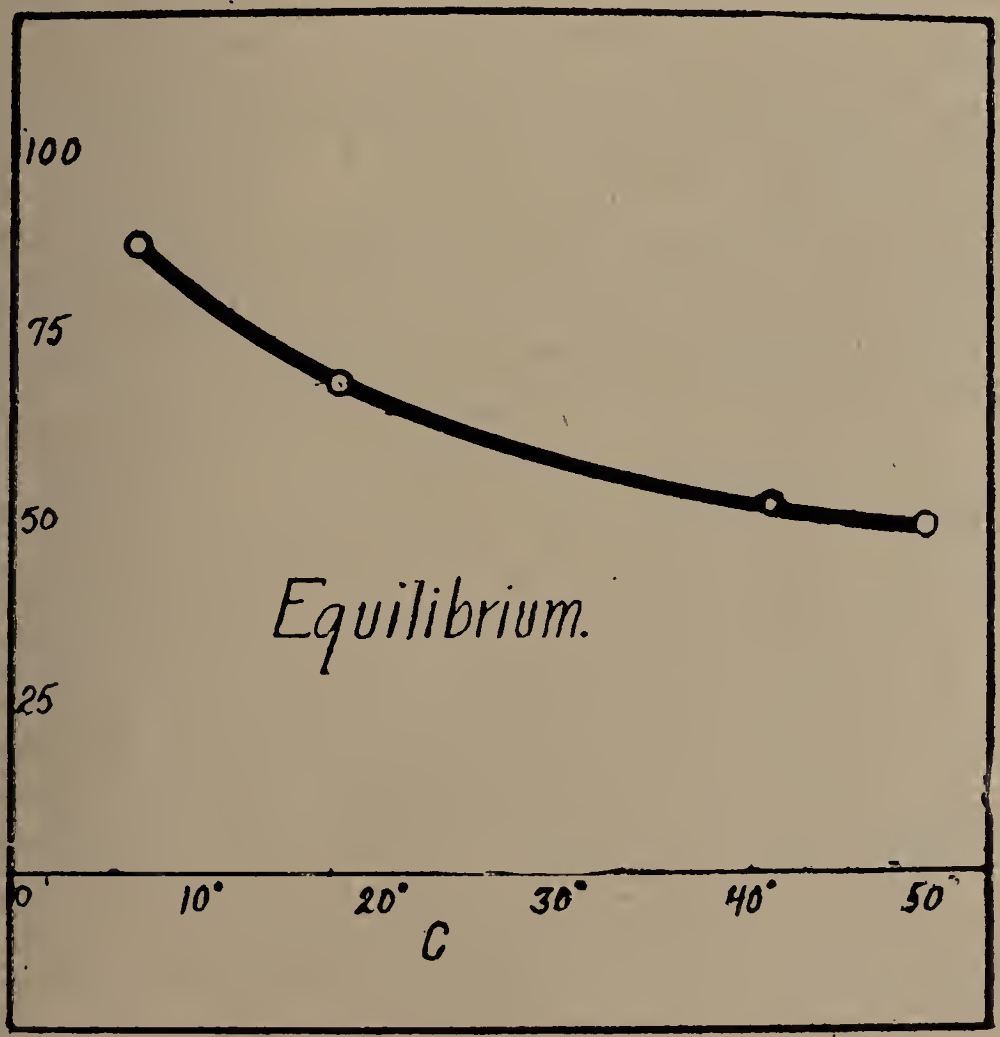
Experimental results.—A mean of two determinations of the heat of change gives 20495 cals. which is less by 4850 cals. than the value calculated from the heats of combustion.

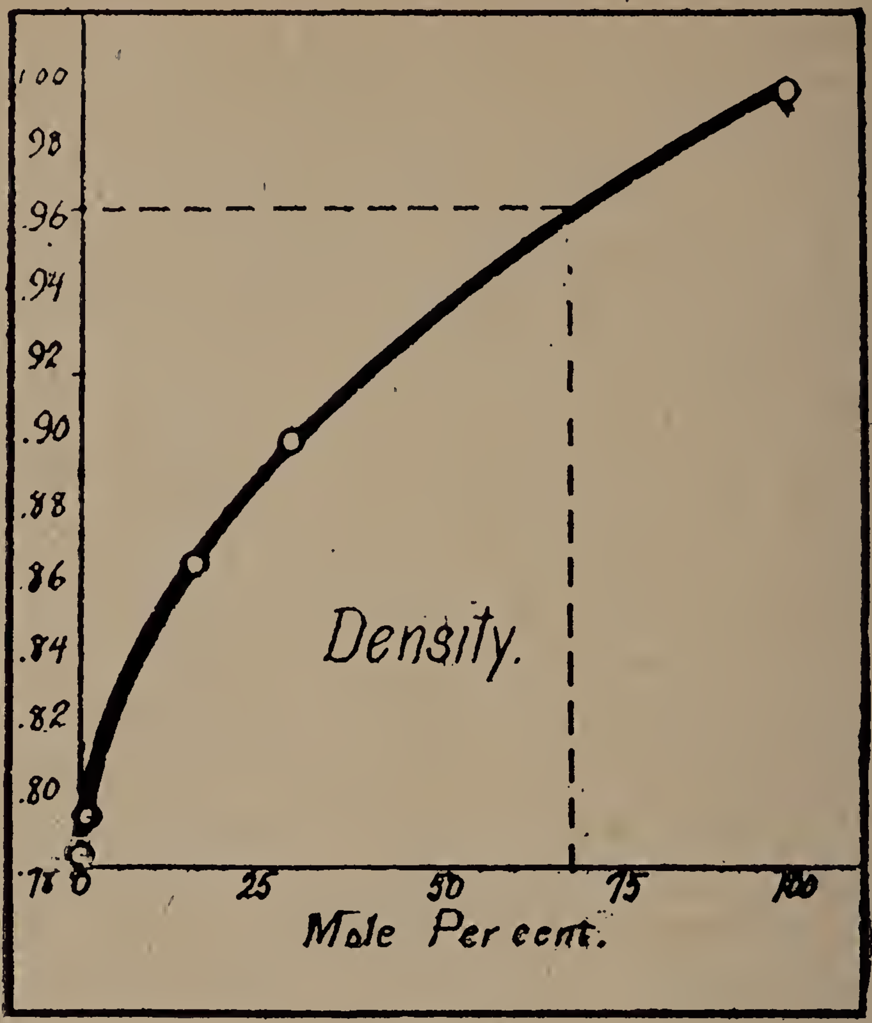
The calculation was made as follows; the value shown by the calorimeter was calculated, and allowance made for the 1.5 mols. percent of paraldehyde contained in the original sample of acetaldehyde. By interpolation on the curve of densities with the change in composition and the curve for the change in equilibrium with the change in temperature it was found possible to obtain a value for the equilibrium mixture at any temperature at which the measurements were made. Corrections were then made for the equilibrium mixture.

The determination of the relation of the composition of mixtures of paraldehyde and acetaldehyde to the density was made in a density bulb standardized with mercury. The measurements of the composition of the solution were made by volume only in small pipettes. Following are the results obtained. Column 1 mols per cent paraldehyde, column 2 the observed density; at 19.3°C.

1	2
0.0	.7834 (from tables).
1.5	.7958
17.0	.8676
29.0	.8999
45.0	.9312
100.0	.9976
Equilibrium Mixture	.9978

The density curve, and the curve for the equilibrium mixture compiled from the work of Holleman, Turbaba, and the above, are given below.





Summary.

1. The heat capacities of paraldehyde, and acetaldehyde for various temperatures are given. 2. The latent heat of fusion for both substances has been determined from the heat capacity curve. 3. The heat of transformation of acetaldehyde into paraldehyde is given. 4. A heat capacity curve for Pyrex glass from -182.5° to 100°C. is shown.

STUDIES ON THE PANCREATIC GLAND.—By HARRY S. MORTON, B. A., M. Sc., from the Departments of Physiology and Biochemistry, Dalhousie University, Halifax, N. S.

(Presented 11 April 1927)

The pancreatic gland exists in the body under the interplay of different influences such as:—

1. The influence of the nervous system.

2. The influence of hormones.

3. The blood supply to the gland.

4. The contractile elements in the gland which may influence the process of discharge of the juice.

5. The alterations of the composition of the internal medium of the body, i. e. of the blood and the body fluids.

These various influences may be affected by changes in the following factors:

(*a*) Changes in the acid-base equilibrium of the blood.

(*b*) Changes in the gas content of the blood.

(*c*) Changes in the content of different hormones in the blood.

I have studied some of these conditions during the work of the pancreatic gland. As a stimulus for a steady flow of pancreatic juice, Pilocarpin was used. This acts by stimulating the nerve endings of the vagus.

Methods.— The following methods were used:—

Cats were anaesthetized with chloralose administered intravenously, 0.1 gram per kilogram of body weight. Cannulae were inserted in the pancreatic and bile ducts, and the duodenum. The pylorus was tied. After the first few experiments the adrenals were removed for reasons to be discussed later. Finally the vagi in the neck were severed and cannulae were inserted in both carotids, one for blood pressure, and the other for arterial blood samples.

Samples of arterial blood were taken at various intervals and the pH,—hydrogen ion concentration—determined by the Dale-Evans colorimetric method[1]. The alkali reserve was measured by the Van Slyke CO_2 method.[2]

Pilocarpin.—Pilocarpin acts on the myoneural connections between the nerves and the epithelial cells, the effect being supposed to be identical with that of nerve stimulation. The pancreatic secretion thus obtained may be influenced by several factors; first of all blood pressure.

I. In one of my earlier experiments it was found that a low blood pressure was more favorable to pancreatic secretion than a high blood pressure.

Experiment No. 4, Fig. 1.

Injection	Secretion	B. P.
1 mg. Pilocarpin	37	140
" "	146	45

Experiment No. 42, Fig. 2.

Injection	Secretion	B. P.
	21	225
1 mg. Pilocarpin	21	80
"	113	40

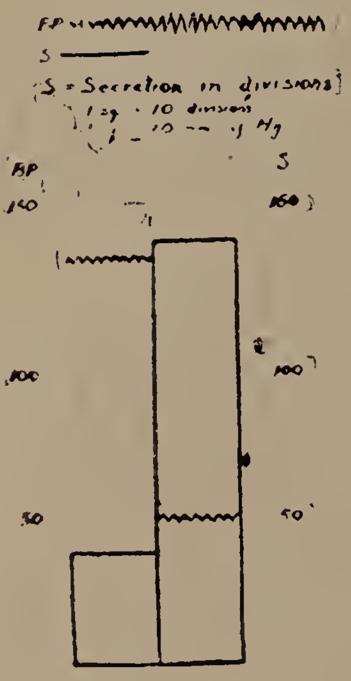


Fig 1

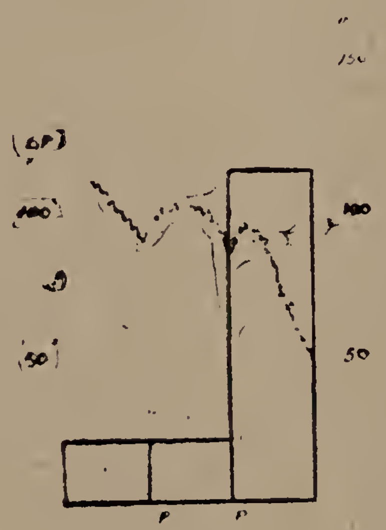


Fig. 2.

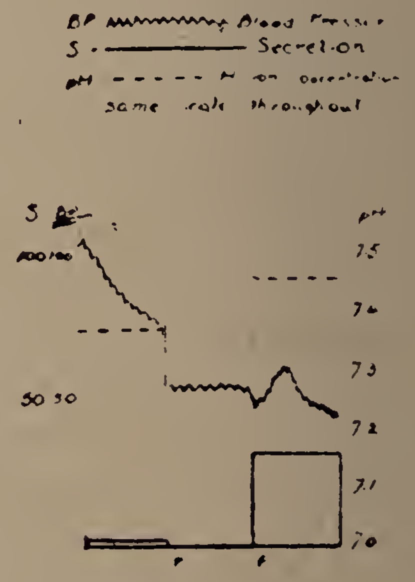


Fig 3.

In the experiments No. 4 and No. 42 the low blood pressure of 45 mm. Hg. is seen to be more favorable than higher values of 80 or more. This may be explained if it is considered that a high blood pressure is due to a constriction of the blood vessels in the splanchnic area. When the vessels in this area are constricted those of the pancreas are particularly affected. This idea has been the outgrowth of work on the antagonism of the pancreas to the adrenal glands. Benedicenti[3] in 1906 described an inhibition of pancreatic secretion following subcutaneous injections of two and three mg. doses of adrenaline. The secretion decreased almost immediately or entirely ceased, this lasted for some time before the rate of secretion returned to normal.' Two years later Pemberton and Sweet[4] independently of Benedicenti found the same relation of adrenaline to the pancreas. From the results of their experiments they conclude that the inhibition of the pancreatic secretion is independent of the rise in general blood pressure, but that it is probably specific. Edmunds[5] repeated the work of Pemberton and Sweet and extended it to other drugs on the rate of pancreatic secretion due to continuous injection of secretin. He concluded (1) that the action of adrenaline in inhibiting the pancreatic secretion could not be considered in any sense as specific, and (2) that the inhibition was probably due to anaemia of the organ because practically all drugs and mechanical procedure which increased general blood pressure, by constriction of vessels, also cause inhibition. Mann and McLauchlin[6] confirmed the work of Edmunds and further extended this work from large pressor doses of adrenaline to small doses which would produce a depressor action on the blood pressure. They found using plethysmographic tracings of the pancreas that depressor doses of 6-10 cc. of 1 in 500,000 adrenaline solution caused decrease in pancreatic volume and rate of pancreatic flow. Thus they concluded that adrenaline whether it raises or lowers general blood pressure, (or it may not have enough action to affect blood pressure at all), usually causes local blood vessel constriction, which reduces the amount of blood passing through the pancreatic gland per unit of time. The fact then that the pancreatic vessels seem to be more sensitive towards the pressor action of adrenaline than those of any other region in the splanchnic area is clear.

Pavlov[7] observed that inhibition of the heart, or constriction in the splanchnic area from stimulation of the splanchnic nerve, prevented secretion. Gottlieb[8] maintains that the rate of pancreatic secretion depends solely upon the blood supply to the gland. Mett[9] obtained a very small pancreatic flow by splanchnic stimulation so that he supposed this nerve must contain both secretory and vaso-constrictor fibres, which he demonstrated by a slow rate of stimulation. Kudrewetsky[10] and Popielski[11] speak only of secreto-inhibitory fibres. Many using secretin found that stimulation of the splanchnics caused vaso-constriction and a decided slowing in the flow of juice. All are agreed, therefore, that stimulation of the splanchnics, either direct or indirect, will inhibit the secretion of pancreatic juice.

Consequently in all my experiments the splanchnic nerves were cut (a) to remove any inhibitory fibres and (b) to remove the vaso-constrictor fibres and in this way lower the blood pressure to a level favorable for the work of the pancreatic gland. (Expts. No. 4 and No. 42). Again as pilocarpin stimulates the secretion of adrenaline which might affect the blood pressure I found it advantageous to remove the adrenal glands in all experiments with pilocarpin.

II. A second effect on pancreatic secretion from pilocarpine was that of saline. In the earlier esperiments only a very poor or even no secretion was obtained; so Dr. Babkin suggested injecting 25 c. c. of 0.9% saline previously.

Experiment No. 43, Fig. 3.

Injection	Secretion	pH
	2	7.37
1 mg. Pilocarpin	0	
"	31	7.46

In this case only a very small amount of juice was obtained.

Experiment No. 44, Fig. 4.

Injection	Secretion	pH
50 cc. Saline	5	7.40
1 mg. Pilocarpin	2659	7.31

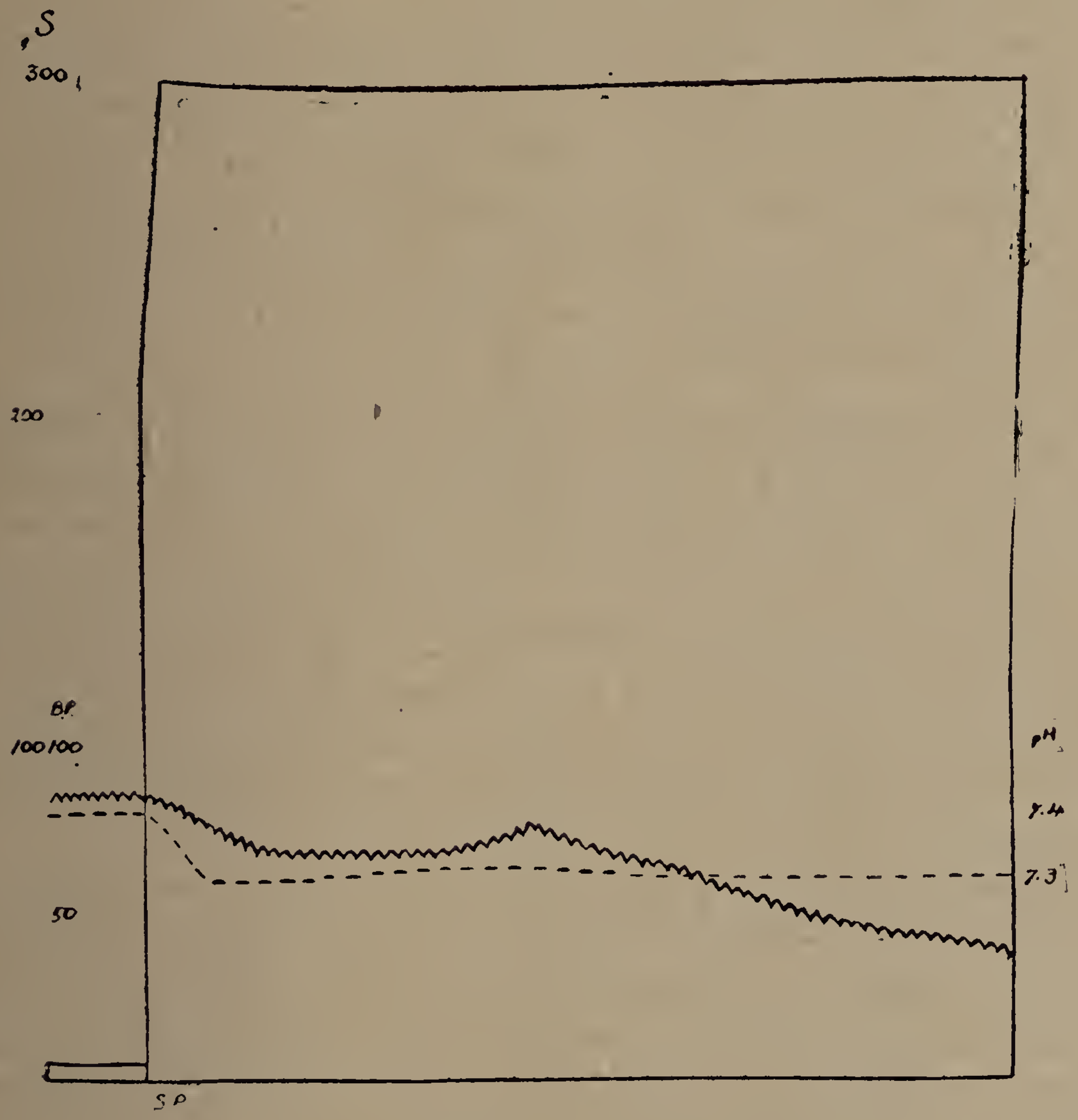


Fig 4.

The beneficial effect of saline on pancreatic secretion is at once evident in experiment No. 44 when contrasted with experiment No. 43. This may be explained: (a) Saline may increase the blood flow through the pancreas as in the case of the salivary glands, or (b) it may increase the permeability of the cells, or (c) it may act by lowering the colloidal osmotic pressure of the blood, as in the kidney, thus allowing water to leave the blood more readily.

The first, must be left for future investigation experiments. The second, will have to be merely a factor until more is known about the influence governing the permeability of cells. The third, is unquestionably a factor, no matter how slight in amount, which aids the blood flow.

III. In the third place, bicarbonate has a marked influence on the flow of pancreatic juice.

It has been demonstrated by Kestner[12] that during gastric secretion the pH of the arterial blood is higher, i. e. the alkalinity is increased. He observed this in a dog with gastric fistula and further observed that if he replaced the gastric juice into the intestine that the pH fell back to the original level, indicating that either; (1) the gastric juice was absorbed and thus restored the normal reaction of the blood or (2) the acid coming into the intestine produced secretin and this in turn provoked pancreatic secretion which being alkaline would tend to make the blood acid, or (3) in the duodenum the acid from the stomach and the alkali from the pancreas neutralize each other giving NaCl and H_2O, the increased alkalinity of the blood due to gastric secretion being counterbalanced by any decrease brought about by pancreatic secretion, so that, both in the blood and in the duodenum equilibrium is restored.

Walther quoted by Babkin, P. 239, noticed in a dog with gastric and pancreatic fistulae a hypersecretion of pancreatic juice preceded by a hypersecretion of gastric juice. Thus one may make a legitimate supposition that the change of the reaction of the blood towards the alkaline side during gastric secretion is favorable for pancreatic secretion.

Furthermore, the various avenues of escape of alkali from the blood must not be forgotten. Thus Carnot et Gruzewska[15] mention an increase of the pH of the bile, i. e. an increase of the alkalinity, as the alkalinity of the blood increases during gastric secretion induced by histamine. They found, however, that under similar conditions the H-ion concentration of the pancreatic juice remained constant, but Cherkess[16] indicates that the total alkalinity of the pancreatic juice is increased after carbonate is injected into the blood. Anrep, Lush and Palmer[17] observed an increase of the titratable alkalinity and the alkali reserve when carbonate was administered intravenously. I have also found this tendency. Thirdly, alkali may be lost through the kidney. Thus we must take into account three different ways for the loss of carbonate from the blood, namely, bile, pancreatic juice and urine.

In my experiments the technique was to obtain a steady flow of pancreatic juice from 1 mg. of Pilocarpin when 3cc. of 3% sodium carbonate were injected intravenously; or to wait until the flow from pilocarpin had ceased, and then inject the same amount of carbonate as above.

Experiment No. 49, Fig. 5.

Injection	Secretion	PH	B. P.
		7.40	70
1 mg. Pilocarpin	135	7.38	60
3 cc. 3% Na_2CO_3	226	7.45	60
"	12	7.55	40

Experiment No. 51. Fig. 6.

Injection	Secretion	PH	B. P.
25 cc. Saline	6	7.38	85
1 mg. Pilocarpin	14	7.39	80
3 cc. 3% Na CO	43	7.42	50
"	203	7.47	25
"	108	7.52	20

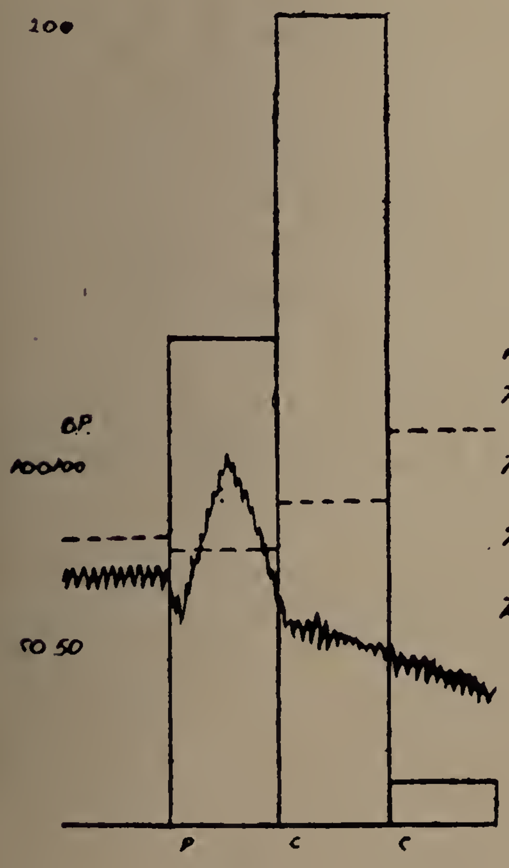


Fig. 5

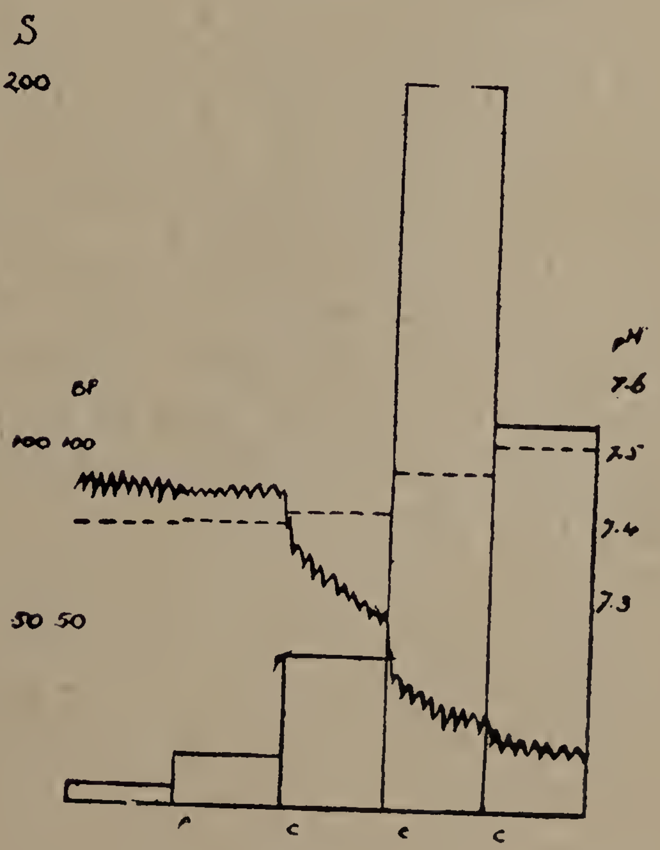


Fig. 6

In experiment No. 49 the first injection of alkali after pilocarpin about doubled the amount of juice, as the pH rose from 7.38 to 7.45. This latter value must have been near the optimum for when pH 7.55 was reached the secretion dropped off to 12 divisions. The falling off of the flow of juice may be partially attributed to a wearing out of the secretory effect of pilocarpin. Expt. No. 51 was slower in reaching its optimum at pH 7.45, thereafter the secretion fell away as the pH increased.

From these experiments it was seen that carbonate often increased the flow of pancreatic juice two and three times or it may give more juice after pilocarpin than pilocarpin alone, yet carbonate alone gave no secretion of pancreatic juice.

This may be due to either or both of two causes. (1) The changed composition of the blood was followed by pH determinations using the Dale-Evans method.

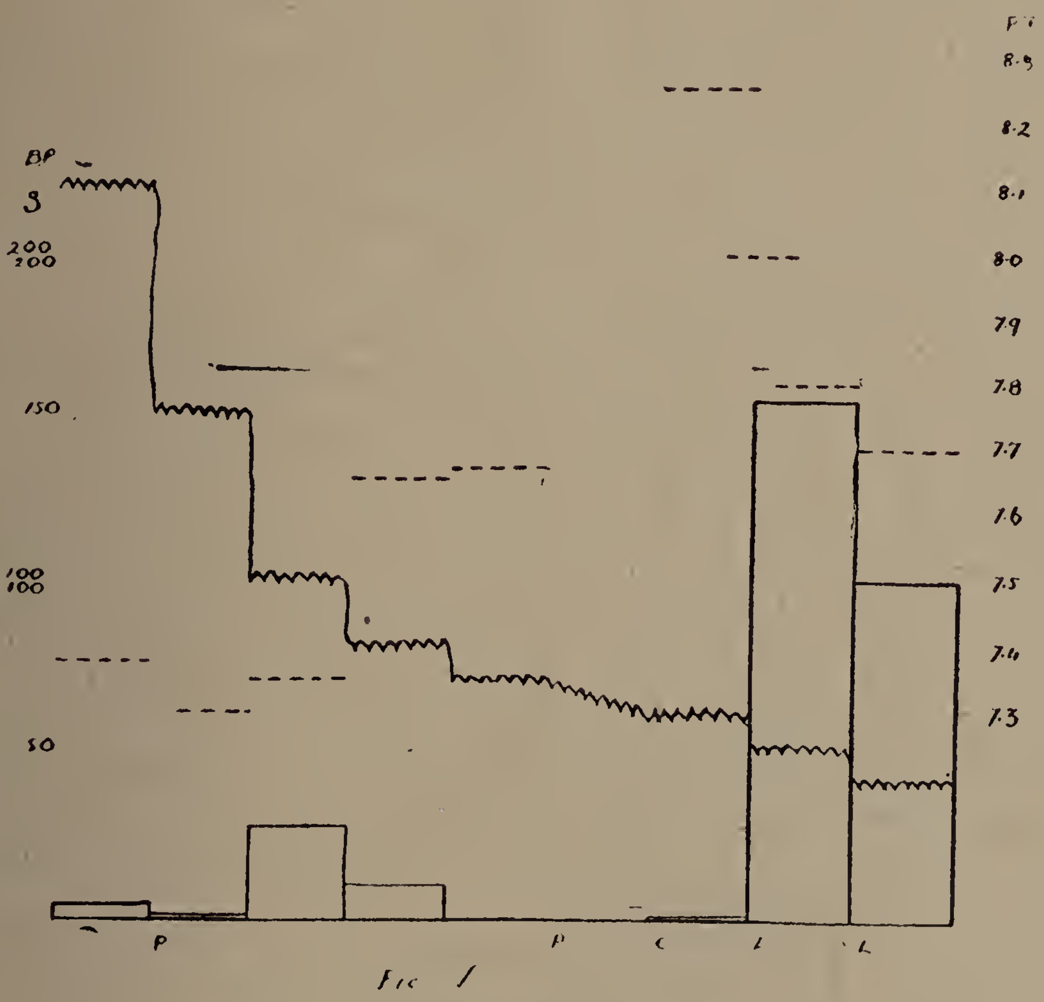
In examining the reaction of the blood no specific range of pH could be found. In each experiment secretion increased parallel to the rise of pH after a while an optimum was reached and then secretion diminished as the pH increased. Further this optimum was found never to be the same in any two experiments, and in two cases was different at different times in the same experiment.

It will be noticed, however, in experiments No. 49 and No. 51, that the pH values run unusually parallel. They increase from pH 7.38 to an optimum at pH 7.45 and pH 7.47 respectively, then one gives 108 divisions of juice at 7.52 while the other yield only 12 at 7.55; thus apparently mapping out a general contour curve, with various points from one experiment nicely filling in the gaps left by the other.

The disillusionment as to the specificity of location of this optimum was effectively furnished by experiments No. 53 and No. 54.

Experiment No. 53. Fig. 7.

Injection	Secretion	pH	B. P.
	4	7.37	220
1 mg. Pilocarpin	1	7.30	150
3 ccs. 3% Na2 CO3	27	7.35	100
"	10	7.65	100
"	0	7.67	80
1 mg. Pilocarpin	0	8.25	70
3 ccs. 3% Na2CO3	1	8.00	60
Lactic acid	155	7.80	50
"	100	7.70	40



Here one sees a very meagre flow of juice from pilocarpin, a fair improvement following carbonate at pH 7.35, complete abolition at pH 7.67, which was not due to a fading out of pilocarpin as more was added with no effect. Then lactic acid was injected into the blood, followed by a copious pancreatic secretion at the extremely high pH of 7.80, the next injection gave 100 divisions at pH 7.70. Here is a case with two different optima at vastly different levels and quite different from those found in other experiments.

Experiment No. 54. Fig. 8.

Injection	Secretion	pH	B. P.
	8	7.37	100
1 mg. pilocarpin	30		60
3 ccs. 3% Na_2CO_3	262	7.46	50–30
"	38	7.47	25
"	24		18
"	19	7.85	18
Lactic Acid	7		12
"	3		12
"	7		12

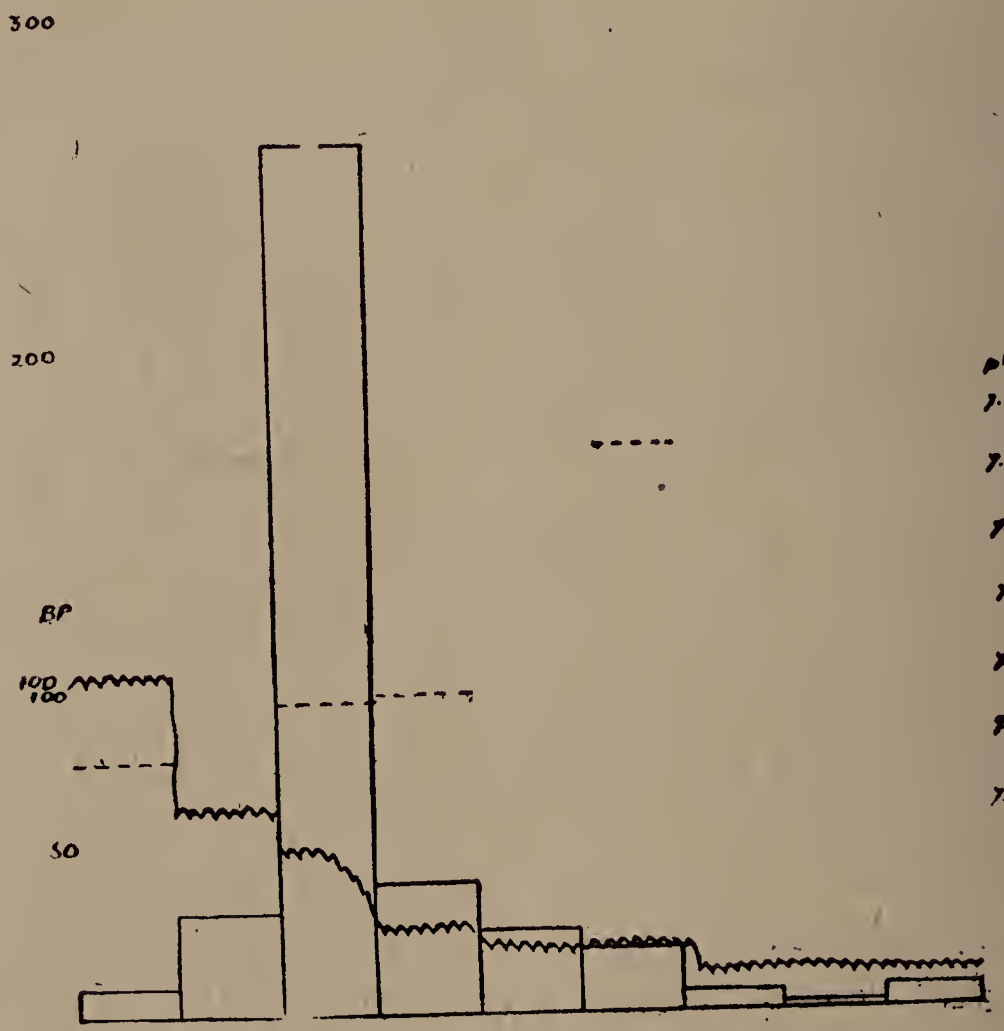


Fig 8

The similarity of this experiment with experiments No. 49 and No. 51 is at once apparent. There is the same level of pH at the beginning and the same optimum point, pH 7.46.

The only difference is the sudden fall at pH 7.47, which afterwards is gradual. Lactic acid did not restore the flow of juice in this case, possibly because the pilocarpin may have been exhausted.

(2) Alkali may increase the blood flow through the gland. This must be examined by blood flow experiments.

Summing up our results it is just possible to suggest an optimum pH for pancreatic secretion somewhere in the neighbourhood of 7.46. This is not to be considered absolute or specific but only in a relative sense.

In conclusion I desire to express my great indebtedness to Dr. Babkin for his advice and criticism, to thank Dr. Young for his supervision, and Miss M. E. MacKay for her assistance during the course of this work.

SUMMARY.

1. A low blood pressure is more favorable for pancreatic secretion than a high blood pressure.

2. Saline is efficacious in pancreatic secretion following the injection of pilocarpin.

3. The splanchnic nerves have an inhibiting action on the flow of pancreatic juice.

4. Carbonate improves the flow of pancreatic juice provoked by pilocarpin up to an optimum H-ion concentration.

5. Above this point it has an unfavorable influence as far as complete abolition.

6. Lactic acid injected into the blood may restore favorable conditions for a flow of juice.

7. No optimum reaction of the blood for maximal work of the pancreatic gland was found. A relative influence of acid and alkali rather than any optimum or specific range of pH is more in accord with observations made.

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A New Determination of the Range of the Alpha Particles of Uranium I and II.—By George C. Laurence, M. Sc., Physics Laboratory, Dalhousie University, Halifax, N. S.*

(Read 6 May 1927)

The ranges of nearly all the elements which emit alpha particles have now been determined accurately. The values for uranium I and II and thorium are less reliable because of experimental difficulties incident to their low activity. Considerable interest, however, is attached to these three, because the validity of Geiger and Nuttall's Law for elements of small decay constant is almost entirely dependent on them. Apparent disagreement, moreover, between their ranges, as measured by Geiger and Nuttall[1], and as calculated from pleochroic halo data[2], has led to a suggestion that there has been a gradual change in their ranges and decay constants throughout geological time. A new determination of the ranges of uranium I and II has therefore been undertaken, using the Wilson Cloud Chamber Method which appeared likely to yield higher accuracy than ionisation or scintillation methods. The extremely small activity of the radioactive material required that the method be modified by the use of a source of large area, the operation of the camera shutter by hand, and the abandonment of shutters to cut off the radiation before the completion of expansions.

Apparatus.—The expansion chamber had a diameter of 6 cm. and a maximum depth of 1 cm. Its piston was operated by a lever, cam and spring mechanism. A fine bore manometer connected to it provided for the measurement of the pressure inside, and a thermometer inserted between projecting flanges of the chamber indicated the temperature. The usual gelatin film kept the air in the chamber moist and served as a conducting electrode for an electric field of 200 volts across the chamber.

---

*Carried out with the aid of a National Research Council Bursary.

[1] H. Geiger and J. M. Nuttall, Phil. May **23**, 439, 1912, and H. Geiger, Z S. f. Phys. **8**, 45, 1922.

[2] J. Joly, Trans. Roy. Soc. of London, **A551**, 51, 1917, and B. Gudden, Z S. f. Phys. **26**, 110, 1924.

The chamber was lighted from the side by a 10 ampere d. c. arc with condensing lenses and an alum solution to absorb heat radiation.

The camera had a lens of 4.5 f. a. and focal length 7.5 cm. and was mounted 20 cm. above the chamber. Kodak Super Speed Motion Picture Film was used, being carried on reels in a box detachable from the back of the camera. Exposures of .4 to .6 seconds were required for sharp photographs.

Source.—The source was prepared by subliming uranium vapor on strips of mica. Small lumps of metallic uranium supported on the ends of tungsten wires formed the electrodes of an electric arc. The arc was struck in a pressure of a few millimeters of air, which was just sufficient to maintain it. The uranium, vaporised by the heat, deposited in a thin uniform film on the mica strips which formed a spiral about 4 cm. in diameter surrounding the arc. A current of 10 amperes for one minute produced a film of the required thickness; .5 mg. per sq. cm., equivalent in absorption to 1mm. of air. A strip thus prepared, 10 cm. long by .8 cm. wide, fastened to the side walls of the chamber with soft wax, served as the uranium source.

Method.—Some of the tracks are formed in the chamber before the expansions are completed and are a source of error. The usual method of stopping the radiation before the completion of expansions by shutters was not practical with so large a source. By making the expansions very rapid, however, the number of tracks formed before the completion of expansions was reduced to less than 2% of the total number, as estimated from the supposition that the number of tracks formed is proportional to the length of time the gas in the chamber is below the required supersaturation temperature. This source of error was therefore negligibly small.

Although provision was made for the automatic operation of the camera shutter, the fact that only one expansion in a hundred produced a track suitable for photographing made it practically necessary to operate it by hand. It was found that the shutter could be opened by hand before the tracks diffused enough to measurably affect the length, so that small error resulted from this cause.

Preliminary Experiments with Polonium.—Thus modified, the method was applied as a check to the alpha particles of polonium. Small pieces of a glass tube that formerly contained radium emanation were used as a source. 400 photographs were taken. After discarding indistinct and doubtful tracks, about 300 were measured on the negatives. The range of polonium determined from these in the usual manner was found to be 3.84 cm. That this is somewhat smaller than the generally accepted value 3.92 cm., is partly accounted for by the penetration of the radium A, radium B and radium D into the glass by recoil.

Uranium Measurements.—About 600 photographs, requiring over 50,000 expansions, were taken. After discarding poor photographs about 370 measurements were obtained. These were corrected for temperature, pressure and vapor pressure. From these data a curve was plotted with range as abcissa and number of tracks of length greater than that range as ordinate. This curve fell off rapidly to zero as the end of the range of uranium II was reached, with no tracks longer than 3.32 cm. The range of uranium II was obtained in the customary manner by extending the slope at the end of the curve in a straight line to intersect the range axis. Superimposed on the curve representing the uranium II tracks is another similar curve corresponding to the shorter range uranium I. Producing the slope at the end of this curve to intersect the uranium II curve exterpolated back gave the range of uranium I.

From the distribution of the tracks about a mean value according to the error law, as found by Mlle. Curie[3], it was shown that corrections of .049 cm. and .055 cm., respectively, should be added to the ranges so obtained to correct for the finite thickness of the source. .018 cm. and .016 cm. were also added to the ranges to correct for the obliquity of the tracks to the plane of the photographic film.

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[3] Mlle. I, Currie, Ann. de Phys. **3**, 299, 1925.

About 20% of the tracks hit the top or bottom of the chamber before reaching the end of their path. These affect the shape of the curve considerably but their distribution is such that they introduce an error of probably less than .005 cm. in the result as obtained above, as was shown by calculating the curve of their distribution from probability considerations.

Fully corrected, the ranges in dry air at 760 mm. pressure and 15°C are—

for uranium I, 2.72 cm.
for uranium II, 3.29 cm.

with an error of probably less than $1\frac{1}{2}\%$ and 1% respectively.

The value for uranium I falls on the Geiger and Nuttall Curve within the limits of experimental error and is quite close to Geiger and Nuttall's value 2.67 cm. The result for uranium II is considerably greater than Geiger and Nuttall's 3.07 cm. Both results appear to be still at variance with the pleochroic halos. Applying Geiger and Nuttall's law to the range 3.29 cm. gives for the decay constant of uranium II, which has never been measured, 2.1×10^{-11} sec.$^{-1}$, and for the half life, 1.0×10^{4} years.

The above values are to be considered as provisional pending the taking of more photographs. It is intended to apply the method also to thorium. A fuller discussion of the method will be given in a subsequent paper.

The pieces of uranium metal required for making the source were kindly furnished by Mr. R. E. Myers of the Westinghouse Lamp Company.

The author is particularly indebted to Dr. G. H. Henderson for suggesting this problem, and for his encouragement and interest in the work throughout the year, and also to the Department of Physics, Dalhousie University, for providing materials, machine work and laboratory facilities.

THE VASCULAR REACTION OF THE PILOCARPINIZED SUBMAXILLARY GLAND TO HISTAMINE (ABSTRACT).—BY MARGARET E. MACKAY, B. A., M. A., Department of Physiology, Dalhousie University, Halifax, N. S.

(Presented 11 April 1927)

It has been noted that under certain conditions the usual vaso-dilator effect produced by stimulation of the *chorda tympani* or by pilocarpin may be changed to a vaso-constriction. This has been explained in two ways: firstly that the chorda contains two kinds of fibres, vaso-dilators and vaso-constrictors. Secondly, that it is due to a reversal of function of the chorda giving in place of acceleration an inhibition of the blood flow. In the course of my investigations it was observed, that an increase of the blood flow after injecting histamine was reversed to a decrease, when histamine was injected following pilocarpin.

Cats and dogs were used, in which the blood flow and secretion were measured from a denervated submaxillary gland. Histamine in doses of 0.25 to 0.5 mg. for cats and 1 to 2 mg. for dogs were administered by intravenous injections.

My results may be summarized as follows:—

1. Intravenous injection of histamine phosphate (**4** mg.) in the cat produces a great increase of the blood flow through the submaxillary gland with *chorda tympani* and sympathetic nerves cut. The same effect is observed in dogs with 1 mg. of histamine phosphate.
2. Intravenous injection of a small dose of pilocarpin, **4** mg. in a cat and 1 mg. in a dog, produces a moderate increase of the blood flow through the submaxillary gland of both animals.
3. Injection of histamine following pilocarpin in a cat causes a diminution in the blood flow through the submaxillary gland. The same reversal effect of pilocarpin on histamine can be evoked in the dog, but with much larger doses of pilocarpin.
4. Atropin restores the vaso-dilator action of histamine, both in a cat and a dog, but to a lesser degree than originally.

In conclusion I wish to thank Dr. Babkin for advice and criticism throughout this work.

The attention of members of the Institute presenting communications for publication is directed to the following notes.

1. Eighty "separates" of each communication accepted by the Council for publication are provided for the author.

2. Drawings which have to be reduced in size should have the lines and letters sufficiently large to be distinctly visible in the print. The drawings should be about double the size of the proposed print. The copy should be carefully typed or in distinct manuscript.

3. The nomenclature of species, etc., should be given in good form, such as is recommended by the authorities directing the abstracting of scientific literature.

4. References to previous or other papers should be made clearly and neatly in the forms approved as in 3.

5. The titles of papers communicated should be made a brief as possible while expressing its subject as definitely as desirable.

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THE

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OF THE

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HALIFAX, NOVA SCOTIA

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SESSION 1927-1928

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* The paging of this Part instead of the Volume Series was accidental.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science

SESSION OF 1927-1928

An Electric Perfusion Pump, with Especial Reference to its Use in Blood-flow.—By O. S. Gibbs, M. B., Ch. B., Pharmacology Dept., Dalhousie University, Halifax, N. S.

(Presented 21 November 1927)

In a previous communication I described an instrument for measuring the renal blood-flow of a fowl[1]. This instrument had certain disadvantages, amongst others, that of offering some resistance to the outflow of blood; being difficult to clean, and not differentiating between changes in the renal blood flow itself, and slowing of the blood stream due to back pressure. As a consequence I have designed an instrument which overcomes these difficulties.

In brief this is an electric pump, so arranged that the fluid flowing in has no resistance to overcome, and when the pump is filled with a certain amount (usually 1 cc.) a switch is closed throwing into action an electric magnet which empties the pump. The pump mechanism simply consists of a piston fitting into a tube, both being covered in a special way by a thin rubber tube. This ensures a perfect joint without undue friction. The piston-rod carries at its other end an armature, on which acts the magnet that pulls forward the piston and thus empties the pump. The piston rod also bears the switch which controls the stroke. Suction stroke is accomplished by allowing the instrument to rest at a slightly lower level than the outflow source, and is so arranged that the downflow pressure just overcomes the piston friction.

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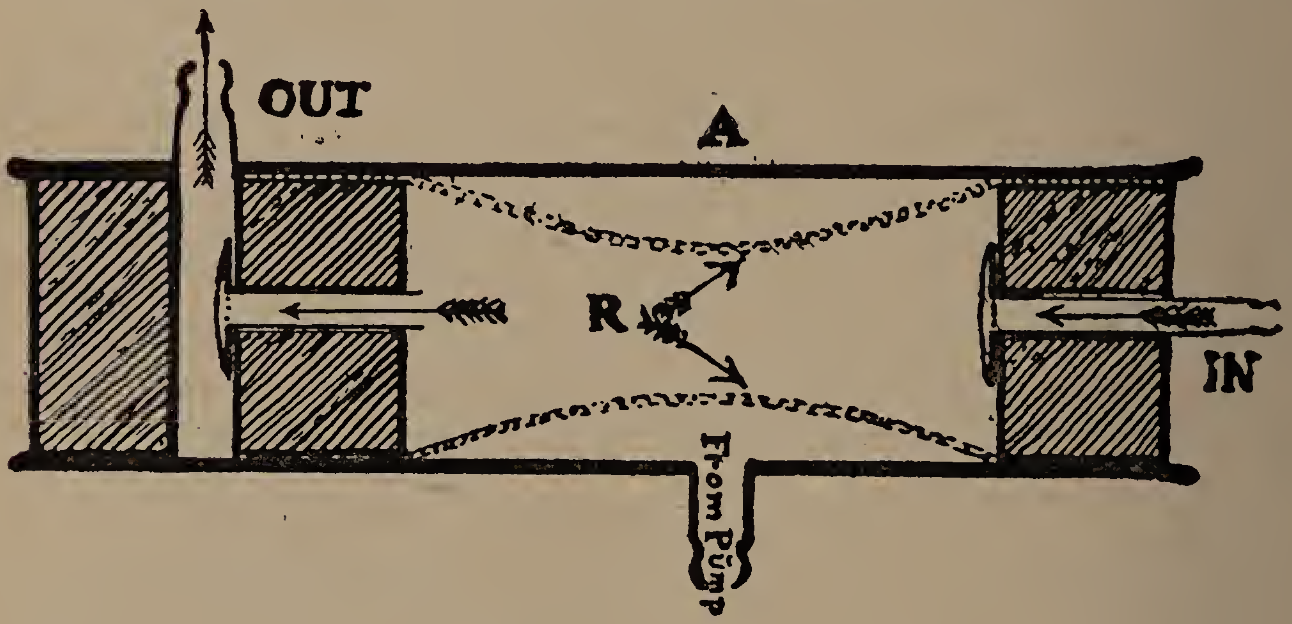
[1] Gibbs, Trans. Nova Scotian Inst. of Sci. 1927, XVII, p. 27.

The valve mechanism is separate from the piston chamber, and is arranged as is shown in the sketch. "A" is a glass part. In this is fitted a thin rubber tube "R", which has a valve at either end.

The pump is connected to the side arm, and acts by compressing the rubber tube "R". In this way the blood, or other fluid being circulated, only comes in contact with a relatively small amount of foreign material. Cleaning is also very simple, and merely consists in most cases of putting the valve chamber under the tap. It is very important that the pump, connecting tubes, and space surrounding "R" be entirely filled with fluid, as air bubbles, being compressible, render the pump inaccurate.



The pump naturally has many uses, but is especially valuable as a constant rate injection apparatus, in which case the rate of the pump is controlled by an electric time clock.

Experiments with this and the previous form of instrument on the renal blood flow of the bird, show that this may be up to 4 litres an hour for one kidney, which is approximately 10 cc. per gram minute. This is a somewhat higher figure than that usually given for the rabbit or dog. The flow varies very considerably, depending on a number of factors. The chief of these is the cardiac output, and the peripheral resistance. The highest flow yet obtained was with the low pressure of 25 mm. Hg blood pressure, indicating that the height of the pressure, in itself, is not the factor of great importance. This observation is borne out by further experiments with adrenalin, in which the rise of pressure thereby induced may be accompanied by no change, an increase, or a decrease in flow, depending on other factors present at the time.

Decreasing the cardiac output by vagal stimulation, or Co_2 inhalation, promptly decreases the flow.

Peripheral dilation by means of histamine, pituitrin, acetyl choline, choline, amyl nitrate, lead, during the pressure fall, to a slowing of the flow. Sometimes however this slowing is momentarily increased. This pressure may fall and is often followed by a rise, especially with choline, and during the rise the flow is often largely increased.

Increasing the bulk of the circulating fluid, and thereby frequently the pressure, leads to an increased flow. The amount of increase is not proportional to the amount of fluid injected, since an equivalent amount of 10% Na_2SO_4 solution always gives a greater flow than Ringer. Uric Acid in hexamine gives results more comparable with the sulphate than Ringer.

The details of the various reactions will be published elsewhere when they are completed.

Conclusions:—(1) The rate of the blood flow through the bird's kidney depends on the cardiac output and the peripheral resistance. (2) Blood pressure measurements are not necessarily correlated with the blood flow rate.

THE ADDITION COMPOUNDS OF HYDROGEN CHLORIDE WITH ETHER AND ACETONE:—BY D. MCINTOSH, M.A., D.Sc., Dalhousie University, Halifax, N. S.

(Read 21 November 1927)

In a paper[1] published recently in the Bulletin of the Chemical Society of Japan, Hirai has given the results of a repetition of the work of Maass and McIntosh[2] on the ether-hydrogen chloride system, and finds only one compound, instead of the three obtained by them. As Archibald and McIntosh[3] have isolated and analysed one compound not found by Hirai I have examined this system again by the method of thermal analysis, and have, I believe, proved that all three compounds are formed.

The freezing-points of the various solutions were determined in a modified Beckmann apparatus with a magnetic stirrer and a platinum resistance thermometer. The materials used were carefully purified and all solutions were made by weight. The method is described in the papers to which reference has been made.

These solutions, as Maass and McIntosh have shown, may be cooled many degrees below their true freezing-points before crystallization takes place. This supercooling can be prevented by "inoculating" the solutions with a minute amount of the ether-hydrogen chloride or bromide complex. This causes precipitation of the $C_4H_{10}O—HCl$ or $C_4H_{10}O—2HCl$ compounds; the $C_4H_{10}O—5HCl$, which is also formed, can be separated only by cooling and prolonged stirring.

The results show maxima in the curves corresponding to the three compounds mentioned. It seems that in Hirai's experiments sufficient care was not taken in preventing supercooling.

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[1] (1926) 123.
[2] J. Am. Chem. Soc. 35 (1913) 535.
[3] J. C. S. 85 (1904) 919.

Hirai has also examined the system acetone- hydrogen chloride, and reports but one compound, C_3H_6O—HCl, while Archibald and McIntosh have made and analysed the compound, $(C_3H_6O)_2$—5HCl.

A few measurements were made of this two component system, and the existence of Hirai's compound and of the more complex one confirmed. These solutions, too, show the phenomenon of supercooling to a remarkable degree, and precipitation of the simpler body can be brought about by the hydrogen chloride or bromide salt.

ON THE DISTRIBUTION OF QUININE IN THE BLOOD.—BY O. S. GIBBS, M. B., CH. B., Pharmacology Dept., Dalhousie University, Halifax, N. S.

(Read 12 December 1927)

Quinine is a substance having the remarkable powers of forming films of high concentration at an interface. As was pointed out by Ramsden[1] it may actually produce solid films.

If quinine be filtered some always becomes absorbed on the filter, and if a celloidin thimble is used to filter a dilute solution, no quinine may appear in the filtrate. Furthermore the concentration inside the thimble falls.

These facts led me to examine the distribution of quinine in the blood; since if quinine were absorbed on the erythrocytes, thus forming a film, though perhaps very thin, of high concentration, it would offer further explanation of its value in the treatment of malaria.

The method of analysis used was described by Ramsden and Lipkin[2] which utilizes the relative insolubility of quinine in a saturated solution of ammonium sulphate to form clouds with Tanret's reagent. The same solution being used to obtain protein free extracts from the blood. Like King and Acton[3] I was unable to confirm the accuracy of this method, which has very many fallacies, and even using a better extraction method was only able to obtain between 70-80% yield of the quinine.

The results of these experiments show clearly that quinine is very difficult to extract completely from the blood debris, and as is to be expected the greater the amount of debris, the greater the loss. In my experiments in which 10 cc. of blood, to which quinine was added, was centrifuged into two layers, the upper one being clear serum, I found like King & Acton more or less equal amounts were extracted from the serum, and the blood cells. It should be noted however that the cell debris is much larger than that of the serum.

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[1] Ramsden, W. Proc. Roy. Soc. 1904, 72, 156-164.
[2] W. Ramsden & Lipkin, I. J., B. M. J. 1918, Vol. I, p. 560.
[3] King & Acton, Biochem. Jour. 1921, XV, 53.

When the blood is haemolysed, and then centrifuged, the two layers (upper 5 cc. and lower 5 cc.) appear identical, although the lower one contains the 'ghosts' of the cells. They also give an approximate amount of debris. Under these conditions however more quinine is always found in the lower layer, varying from 6-40% more.

This fact appears most easily explained by assuming the adsorbtion of quinine onto the 'ghosts', and if this be true onto the intact cells. In any case the diffusion of quinine into the cell, even if it occurs, would probably be a very slow process; whereas, as Rona & Block[4] point out, the distribution of quinine takes place with "unmeasurable rapidity."

Summary.

1. King and Acton's results on the use of Ramsden & Lipkin's method are completely confirmed.

2. Using a modified technique very similar to these authors between only 70-80% of the added quinine has been recovered.

3. Under the conditions of the experiments the yield from the serum approximately equals that from the blood cells.

4. Quinine is probably adsorbed onto the blood cells.

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[4] P. Rona & Block E. Biochem. Zeit. 1922. 128, p. 169.

NOTES ON ISOMORPHISM IN OXONIUM COMPOUNDS.—By D. McIntosh, M. A., D. Sc., Dalhousie University, Halifax, N. S.

(Presented 9 January 1928)

The two classes of oxonium compounds formed by the union of organic substances containing oxygen with the halogens and with the halogen hydrides show so many differences in their properties, that different constitutions must be ascribed to them. Since chemical constitution and isomorphism are sometimes related, I have, in this preliminary study, attempted to group those compounds having the same crystal form together, by finding the effect of one solid compound on the supercooled melt of another.

Crystallization is brought about in these supercooled solutions by low temperatures applied locally,—for example, a drop of liquid air or a piece of wire cooled in liquid air proves effective. But, if the solution be cooled to a low temperature uniformly, a glass is formed, and crystallization does not take place.

Gernez[1] showed many years ago that isomorphous salts promote crystallization in aqueous, supersaturated solutions, by precipitating magnesium acetate from its supersaturated solution by means of barium acetate. Boisbaudron confirmed this, but noted that often a greater supersaturation (or lower temperature) was necessary when an isomorphous salt was substituted for the salt in solution. A supersaturated solution of nickel sulphate was precipitated by zinc sulphate, but not by ferrous sulphate until further concentrated, and at times the crystal form varied with the isomorphous salt used.

As an example of the method of procedure, a mixture containing hydrogen chloride and ether in the proportion of one or two molecules of the former to one of the latter was prepared. This was cooled five degrees below its freezing temperature and was then "inoculated" with a few crystals of another compound, stirred gently and observed for some time. The compounds obtained from the following systems were examined in this way:

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[1] Ostwald, Lehrbuch 2, 1, 740.

Ether with hydrogen chloride, bromide and iodide; alcohol, acetone and ethyl acetate with hydrogen bromide; ether, alcohol, ethyl acetate and acetone with bromine and chlorine; and methyl ether with hydrogen bromide and iodide.

Supercooled $C_4H_{10}O\text{-}HCl$ is precipitated by its own crystals immediately, and also by $C_4H_{10}O\text{-}HBr$ and by $C_4H_{10}O\text{-}HI$, the latter after some little time, but not by the hydrobromide or iodide of methyl ether, nor by other salts such as acetone-hydrobromide or ether-chlorine. $C_4H_{10}O\text{-}2HCl$ is precipitated by its own crystals, by $C_4H_{10}O\text{-}2HBr$, but not by ether-hydrogen iodide (an additional proof to previous work that this is the only compound formed), nor by methyl ether-hydrobromide. The 5 HCl complex is not affected by any of the oxonium compounds, but must be precipitated by low temperatures.

The oxonium-chlorine compounds are precipitated by the corresponding bromine compounds, but not by other compounds of the halogen or acid classes.

From these experiments it seems probable that compounds of each class made with the same organic substances are isomorphous, while those made with different, though closely related, organic compounds are not.

A New Method of Measuring Blood-Flow (a demonstration of the apparatus):—By O. S. Gibbs, M. B., Ch. B., Pharmacology Dept., Dalhousie University, Halifax, N. S.

(Presented 19 March 1928)

Blood is allowed to flow through a very light valve in a small balloon surrounded by water in a glass container. As the balloon expands the surrounding water is displaced into a Condon recorder[1]. By arranging the outflow pipe at a suitable height no resistance is offered to the blood flowing into the balloon.

When a certain amount of water has been displaced by the blood (which may be varied from 2.5-5.0cc.) into the recorder, this tilts and closes the contact. The results of this are three-fold. Firstly the contact is recorded on the drum, the current is passed into an electric valve which closes the outlet pipe, but opens a valve leading to a water pressure of about two metres. Water rushes into the balloon chamber and compresses the balloon forcing the blood onwards through an outlet outlet valve which are similar to those described in a previous paper.[2]

During this time however the contact on the recorder is held closed due to the action of a small electric magnet which is also activated by the same current as the valve circuit.

When the balloon is emptied the current is cut off and the recorder and electric valve return to their original positions. The means of breaking the circuit is by using a mercury manometer in the water pipe near the valve. When the valve opens, naturally the pressure falls momentarily in the manometer. As however the balloon is emptied the pressure once again rises in the manometer, but the inertia of the mercury causes it to overshoot the normal level. This overshoot is utilized to break momentarily the circuit, which immediately releases the recorder contact, and thus the break becomes permanent.

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[1] Condon, N. E. Proc. Physiol. Soc., June, 1913.
[2] Gibbs, O. S. Trans. Nova Scotian Inst. of Sci., 1928.

This instrument works up to a rate of about 15 litres per hour, and fulfils the necessities of my work which requires no resistance to the outflow of blood, and a positive return. Besides this the apparatus can be strongly built and in consequence requires little attention during an experiment.

Full detail of this apparatus have been sent to the Journal of Physiology.

EXPERIMENTS ON THE REMOVAL OF SULPHUR FROM ILLUMINATING GAS BY ACTIVATED CARBON: (ABSTRACT).—BY E. W. TODD, B. A., Department of Chemistry, Dalhousie University, Halifax, N. S.

(Presented 9 January 1928)

Two varieties of activated carbon, Norit and Rotite, were used in the experiments.

The amounts of sulphur in the gas were determined in the ordinary way by burning the gas.

A few of the results obtained with Rotite are given below.

Per 100 *cu. ft. of gas measured at* 62°*F. and* 30 *inches pressure*:

(a) Experiment without activated carbon: 48.6 grains of Sulphur.

(b) Experiment with activated carbon 5.6 grains.

(c) Experiment without activated carbon: 47.5 grains.

Average of (a) and(c) = 48.05 grains.

Sulphur remaining in the gas = 5.6 "

Therefore, the sulphur has been reduced to about one-eighth of its original value.

Other experiments gave similar results.

The weight of activated carbon used was about 125 grams. These experiments were sufficient to show that the amount of sulphur in the gas can be reduced considerably by the method used.

The 12 inch tower containing the carbon was next connected with the gas supply, and between three and four hundred cubic feet of gas passed through it, in order to see how soon the carbon would become "saturated" and, therefore, ineffective. Then, gas was again passed through the tower and burned, in order to see how much sulphur the carbon was now capable of removing.

The sulphur was found to be reduced, but not nearly to such an extent as before, — approximately to one half of its value, as compared with one-eighth in the case of the fresh carbon.

Next, an attempt was made to "revivify" the carbon in the following manner: The carbon was removed from the tower, and heated in an open iron crucible, with occasional stirring, over an ordinary Bunsen flame for about two hours.

The carbon after cooling was then replaced in the tower, and tested for its ability to remove sulphur from the gas.

Per 100 *Cubic Feet of Gas at N. T. P.*

1st.	experiment,	with activated carbon,	2.97	grams
2nd	"	"	2.69	"
3rd.	"	"	3.83	"
4th	"	without activated carbon	15.38	"

So that, in the first two experiments, about one-fifth or one-sixth, and in the third, about one-fourth of the sulphur was left in the gas.

Therefore, the carbon has been, to some extent, revivified by the method adopted.

It is intended to try other methods of revivifying the carbon.

Other experiments, made with Norit, gave results in which the sulphur was reduced to about one-seventh of its original value—much the same reduction as with the Rotite.

Summary.

It has been found that the two forms of activated carbon tried were very effective in removing sulphur compounds from illuminating gas, and that the carbon could be revivified to a considerable extent by heating it in a vessel open to the air.

PRELIMINARY NOTES ON THE MITOCHONDRIA OF THE PARATHYROID OF THE WHITE RAT.—BY SINA S, SINGER, SC. M., From the Histological Laboratory of the New York University Dental College and the Histological Laboratory of Dalhousie University, Halifax, Nova Scotia.

(Presented 10 April 1928)

This paper embraces a study of the mitochondrial granules in the parathyroid gland of the white rat.

The mitochondria, now recognized as a definite class of granules, are found in the cell protoplasm of almost all living tissues. Therefore the presence of the mitochondria must have an important bearing on the function of the given cell. Many observers express different theories and have hazy ideas about the behaviour of the mitochondria.

The real function of the mitochondria is still unknown. Perhaps, this is due to the fact that the study of mitochondria is recent, having been begun within the last two decades. The variety of names attributed to the same kind of granules also was a hindrance to the progress of the study of mitochondria. At present, the mass of literature concerning this subject is largely descriptive.

However, E. V. Cowdry (1918) has presented experimental results and careful studies of the true mitochondria granules from unicellular living cells up to the highest type of organism.

In order to give a historical review of mitochondria, only a few of the more important investigators and their contribution towards this study will be mentioned.

Flemming's (1882-1884) "fila" theory of the constitution of protoplasm proves his careful study of granules. Altman (1890) studied all types of tissues only on the vertebrata, while F. and R. Zoja (1891) focussed their attention on invertebrates. The Zojas concluded that the mitochondria play an important rôle in nutrition, which view is also held at present.

For an interval of ten years after this time, the study of the granules of the cytoplasm was neglected. Attention was devoted solely to the nucleus and its granules. The fixatives used for nuclear details contained mixtures of mercuric chloride, alcohol, chloroform, or acetic acid, because of their rapid penetration and their action on chromatin. These solutions act fatally on the mitochondria unless certain precautions are taken, for the mitochondria are dissolved by such treatment.

In 1889 Benda had introduced the term "mitochondria" for a definite class of granules. Meves (1908) worked on the granules of the cytoplasmic embryonic tissues, and found mitochondria in all embryonic tissues. From this he deduced that the mitochondria have an influence on the modification and on the differentiation of cells, in spite of the fact that at that time the origin of these cell differentiations had been more or less explained to the satisfaction of cytologists without reference to mitochondria. His theory that mitochondria play an important part in heredity attracted world-wide attention, being supported by the discovery that the mitochondria of the spermatozoon enter the egg of fertilization. Simultaneous with these facts, strong support by Morgan and others was given to the chromatin hypothesis.

Regaud (1908) studied the chemistry of mitochondria, proving them to be a compound of phospholipin and albumin, and progress since that time may be attributed to this information regarding the chemical constitution of the mitochondria. He regarded mitochondria in the same light as do the modern physiological chemists and pathologists and tended to promote their interest in phospholipins.

M. R. and W. H. Lewis (1914) devised a method by which they are able to select a certain group of mitochondria and observe their behaviour for a considerable length of time. In 1915 they found that mitochondria continually change in shape by bending in various directions, elongating, contracting, thickening, thinning, etc. The Lewis' also observed mitochondrial networks in living cells of tissue cultures. By changing the osmotic pressure of the fluid bathing the cells in their tissue cultures, they found they could modify the shape of the mitochondria. There was a marked increase when hypotonic solutions were used, a distinct decrease with hypertonic solutions.

Goetsch (1916) reported that the mitochondria were definitely increased in the cells of pathological tissues. In 1918 he carefully studied mitochondria in twelve simple goiters and fifty exophthalmic goiters and one hundred and twenty-five adenomas. According to Key (1924) Goetsch found in this series that in adenomas with toxic symptoms, the mitochondria were present in excessive numbers; in exophthalmic goiters they were present in enormous numbers; in simple colloid goiters, without toxic symptoms, few or practically no mitochondria were present, while in hypertrophy with symptoms, they were present in moderate numbers. These results indicate that the toxicity of the thyroid varies directly with its mitochondrial content. Goetsch concludes "that a study of mitochondria was the only reliable method of determining the state of activity of certain pathologic thyroids, as in adenomas, every type of growth and degree of hyperplasis might be present and the symptoms still vary from hypothyroidism to hyperthyroidism."

From the foregoing brief historical review one can see that the actual function of the true mitochondria is still doubtful, but it is evident that they are destined to play a noteworthy part in medical research. Further work in the study of the chemistry and physiology of mitochondria will, undoubtedly, aid in understanding the behaviour and relation of these granules to the normal and pathological cells in the given organism.

Throughout this work the term "mitochondria" is used to designate a specific class of granules. An adjective such as rod-like, granular, short, and long is almost always added to the term "mitochondria" to describe or limit its meaning.

The work for this paper was done in the histological laboratory of New York University Dental College (1926-1927) and in the histological laboratory of Dalhousie University (1927-1928) under the direction of Professor Raymond J. Bean of the Laboratory of Histology and Embryology, Dalhousie University.

Parathyroids taken from ordinary stock colony rats of various ages were examined. The 120-day-old rat is taken as the standard. The rat diet includes milk, water, corn, and bread daily and contains fish and cabbage once a week and meat and lettuce twice a week.

For all the material prepared the following technique was employed: A rat was killed by ether. By means of iridectomy scissors, the parathyroid with a piece of thyroid tissue was removed and then placed in a given fixative, dehydrated, washed, cleared, and embedded in paraffin and sectioned. The thickness of the cross sections varied from 3 to 5 microns. The ordinary egg-albumin-water method was used for mounting and various stains tried. Because the mitochondria are very sensitive, and their shape often changed by slight injury, great care should be taken in handling them. It is advisable to put the given tissue into the fixation fluid immediately, in order that it may not dry.

Three types of cells have been recognized in the parathyroid gland of the white rat (Hoskins, 1924). The chief cells predominate and are found in all parathroids. In some cases a zone of cells which resist ordinary staining methods is found about the periphery of the organ; and a third type, the chromophile may occasionally be distinguished. These chromophiles described by Dr. Hoskins lie at the margin of the gland, and are believed to be due to faulty technique in the preparation of the specimen. In addition to these types, chromophile cells have been observed lying scattered among the chief cells, which will be discussed later as a fourth type.

Regaud's (1910) iron hematoxylin method of Heidenhain: Fixation:

(1) Fix in 3 per cent potassium bichromate 80 volumes, commercial formalin 20 volumes, for 4 days, changing every day.

(2) Mordant in 3 per cent bichromate for 7 days, changing every second day.

(3) Wash in running water hours, dehydrate, clear, embed and section 4 microns, and fix to slides by albumen-water method.

Staining:

(1) Pass down through touol, absolute alcohol, 95 per cent, 70 per cent, and 50 per cent alcohol, about 30 seconds each, to aq. dest. in staining jars.

(2) Mordant in 5 per cent iron alum at 35 degree C for 24 hours. Rinse in aq. dest.

(3) Stain for 24 hours in hematoxylin made up as follows: Dissolve 1 gm. pure crystals of hematoxylin in 10cc. of absolute alcohol and add 10cc. of glycerine and 80cc. of distilled water.

(4) Differentiate in 5 per cent iron alum under microscope.

Note: The crucial point in the technique is passing from the mordant to hematoxylin. The slides must be rinsed in distilled water, otherwise, the iron alum will form a dense black precipitate in the stain. On the other hand, if they are rinsed too much, all the iron alum mordant will be removed. It is necessary to strike the happy mean in which a darkening of the hematoxylin alone occurs. It is always difficult to get good hematoxylin, and I find it best to keep on hand a ripe alcoholic solution.

Following the procedure described above, mitochondrial granules were found in every cell of the parathyroid gland. However, the distribution and morphology of these bodies varies with each cell. Most cells are polygonal in shape, though some are elongated or triangular. The part of a polygonal cell nearest the nucleus is designated as the "proximal part." In the elongate and triangular types, the respective parts may be designated by the terms 'basal" and "apical."

In the parenchyma many chief cells show an abundance of mitochondria in the proximal region, which gradually diminish in numbers towards the apex. In other cases, the distribution of mitochondria in parenchymatous cells may show a complete reversal of this order. They may be grouped in the form of a pyramid with its apex directed towards the apex of the cell, or in rare instances chief cells show at the apex scattered longitudinal rods similar in appearance to the tubercle bacillus. In contrast to mitochondria, the granules of the vesicular nuclei take the stain more readily and appear as opaque blotches.

On the concavity of the nucleus of some chief cells, an irregular line of granules was found by focusing carefully. This type of mitochondria shows a strinkingly close similarity to G. Bobeau's (1911) illustration. In other chief cells where the nucleus was at the basal membrane, the mitochondrial granules were at the side of the nucleus. It appeared, in certain instances, that the cell walls were more darkly stained at the base. This brings out the fact that in these examples the mitochondria are concentrated in the basal portion of the cell.

The second type of cell found in the parenchyma, forming the light zone at the periphery, has a paler cytoplasm with darker granules which, on focusing, appear to be mostly rod-shaped or granular. These granules are near the nucleus projecting in rays towards the apex of the cell. These cells are best demonstrated when Regaud's formalin bichromate mixture is used a fixative and in conjunction with the iron-hematoxylin staining method of Heidenhain. The mitochondrial granules show blue-black on an iron-gray background, while the thick cell membranes and intercellular connective tissues are also clearly defined.

The third type, the marginal chromophile cell, is not always present in the parenchyma of the parathyroid glands. The mitochondrial granules are spherical and evenly distributed through the cytoplasm. Considerable difficulty was experience in working out a technique satisfactory for a clear demonstration of these cells. In most cases, the cytoplasm stains so deeply that the mitochondrial granules cannot be distinguished.

The fourth type is the central chromophile cell. Its nucleus is smaller and stains darker than that of the chief cell, and the cell membrane is not clearly defined. In general, the cytoplasm is characterized by large numbers of deeply stained spherical granules, but occasionally a crescentic aggregate of granules may be clearly distinguished lying close to the nucleus in the apical portion.

Comparing the four different types of cells, it is certain that the chief cells have the largest proportional number of mitochondrial granules. Often the whole parenchyma in the parathyroid gland of the white rat is composed of these chief cells. The fact that they are common to every parenchyma and that the three other types of cells are variable in their presence also adds to the possibility that the chief cell is of greatest importance. Hoskins (1924)—"The chief cells are the only functionally impurtant type in the parathyroid of the white rat."

The second type of cell with the paler cytoplasm is in the minority, but this fact should not be interpreted to mean that these cells have no functional value. This point of view is not in accord with that of Dr. Hoskins (1924) who states—"It is possible, however, that the light zone is the result of some slight variation in the technique and is quite without functional significance."

The third type of cell in the parenchyma, in 95 per cent of the examined tissues, exists as a single marginal layer which occasionally invades the interior of the parenchyma en masse. This type of cell, is, perhaps, due to a variation in technique.

The type of cell designated as the fourth type may be the result of improper staining, because some sections that take a uniform stain show the absence of dark nuclei.

In addition to a study of the parenchyma of the parathyroid gland, an attempt was made to determine the existence of mitochondria in the connective tissue cells of the supporting framework. Of all the stains tried, Heidenhain's iron-hematoxylin and Bensley's copper chrome hematoxylin are the only stains that bring out the connective tissues which are fibrous strands varying in thickness. Embedded in these fibers are large cell bodies filled with dark granules. The nucleus of the connective tissue cell is more resistent to this staining procedure than the cytoplasm. Often the connective tissue cells are blurred and look like dark blotches, but, wherever the cytoplasm is less deeply stained, mitochondrial granules are visible. Here again the granular-shaped type of mitochondria are found to predominate.

Summary and Conclusions.

From the work described above on mitochondrial technique, the cells in the parenchyma of the parathyroid gland of the white rat may be divided into four types.

A—Chief Cells.
B—Light Cells.
C—Marginal Chromophiles.
D—Chromophiles.

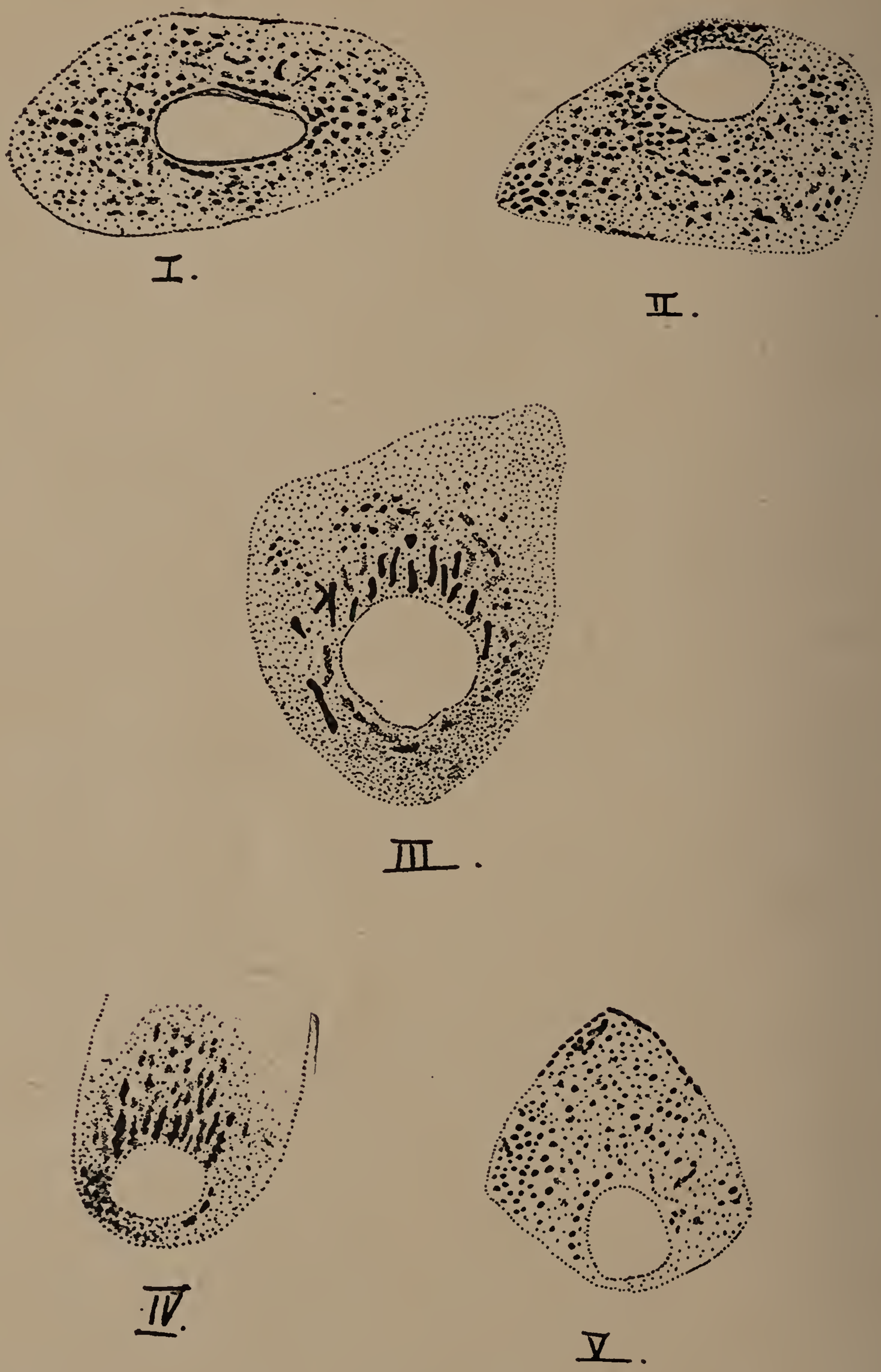
Note:—Hoskins (1924) classes C and D as one type.

A—Chief Cells.

The nucleus of the chief cell is large. The mitochondria are scattered throughout the cytoplasm and are most densly grouped in the proximal portion, being less concentrated but more distinct in the rest of the cell. On one side of the nuclear wall are short filamentous mitochondria with bulb-like swellings. There is a light space between these granules and the nuclear wall. In the distal part, large spherical mitochondria are very numerous; few are found at the side of the walls of the cell.

B—Light Cells.

In the second type of cell, the distribution of the mitochondria is occasionally similar to that of the chief cells. However, the granules are fewer, more distinct and on a paler protoplasmic background. The nuclear wall is encircled by a spherical, light-stained string of mitochondria. By careful focusing, distinct, .ear-shaped granules of uniform size, somewhat darker than the protoplasm, become visible. Frequently, some



CHIEF CELLS SHOWING DIFFERENT TYPES AND DISTRIBUTION OF MITACHONDRIA IN PARATHYROID OF WHITE RAT.

—*Sina S. Singer.*

larger isolated, spherical granules appear. The granular-shaped mitochondria predominate in this type of cell. At the extreme distal portion are found single rod-shaped mitochondria, four to five in number, all having the same thickness. These are difficult to distinguish at first glance. Just above the nucleus, appearing to come from it, is a cord-like arrangement of mitochondria, resembling minute thumb-prints. Bunches of light-stained granular mitochondria are often present at the sides of the nucleus.

C—Marginal Chromophiles.

The third type of cell is not always present in the parenchyma. Its presence is often attributed to variations in mechanical techinque This cell appears in a single layer around the margin of the gland. Sometimes this layer invades the interior of the cell. At the margin of the parenchyma, the cells are very dark, and it is difficult to distinguish the nucleus from the cytoplasm. In the cells which invade the parenchyma, however the difference is sharply marked because the cytoplasm becomes lighter. Only spherical mitochondria are common to this type.

D—Chromophiles.

Most chromophiles are elongated cells containing a very dark nucleus and a lighter protoplasm. These cells are very few. The mitochrondria in them resemble in number, structure and location, those of the chief cell. A colorless area is almost always found between the nucleus and the protoplasm.

E. In the connective tissue cells, the nuclei are very dark and kidney-shaped. The cell walls are not distinguishable. On both sides of the nucleus a lighter stained protoplasm contain granular mitochondria.

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A VERMIFORM APPENDIX IN THE DOMESTIC CAT.—BY MARJORIE F. ELLIS, B. A., Department of Zoology, University of Dalhousie, Halifax, N. S.

(Read 6 February 1928)

The appearance of the vermiform appendix seems to be associated with the enlargement of the caecum which is found in animals that live on a vegetal diet. In flesh-eating animals the appendix does not appear. The rabbit, whose diet is herbivorous, has a large caecum and an appendix. In man a medium sized appendix is present.

The purpose of this paper is to describe the apparently very rare occurrence of a vermiform appendix in the domestic cat. Standard reference works on the anatomy of the cat such as Davidson and Stromsen and Reighard and Jennings state that the appendix is absent in the cat, and cite no exceptions to this rule.

The material discussed was found during dissection in one of the classes in the Zoological Laboratories at Dalhousie University.

During embryonic development of man in the posterior half of the intestinal loop in the 7.5 mm. embryo there is an abrupt enlargement of the entodermal tube which marks the junction of the large and small intestines. This enlargement takes place wholly from the ventral side of the tube. The lumen of the large intestine extends slightly forward into the ventral swelling, forming a shallow blind pouch. This structure is considered to be the beginning of the caecum. The distal end of the caecum early lags in development and in the 65 mm. embryo the distal end is easily distinguished from the rest of the caecal pouch by its difference in diameter and is termed the vermiform appendix. The appendix is relatively long in the embryo and relatively short in the adult.

In the cat there is normally no appendix, and embryonic stages fail to indicate any.

The specimen under discussion exhibits an apparently true vermiform appendix forming a tubular projection on the distal end of the caecum. It is 15mm. long and 3.5 mm. in diameter at its widest point tapering slightly at its distal end. There is a distinct lumen which extends throughout its entire length. The wall of the appendix is 2.5 mm. in thickness. The appendix receives its blood supply from the vessels that supply the caecum, namely the *arteria iliocolica* and the *vena iliocolica.*

The wall of the appendix is found when sectioned to be made up of several layers which are roughly comparable to those which make up the wall of the digestive tract.

There is on the outside a thin serosa underlying which is the muscular coat consisting of a peripheral longitudinal muscle layer and a more mesial circular muscle layer. The longitudinal muscle layer is 40μ in thickness. The circular muscle coat is 110μ in thickness and consists of spindleshaped involuntary muscle cells with greatly elongated nuclei.

Beneath the muscular coat there is a wide region of densely nucleated diffuse lymphatic nodules. These form a broken ring of this tissue, occupying the larger part of the sub-mucosa which is reduced to a thin peripheral layer beneath the muscles through which a large number of blood vessels run. A thin layer, the muscularis mucosa, separates the mucosa from the lymphoid tissue.

The mucosa, which is approximately 380μ in thickness, is invaded by numerous glands which are similar to those in the mucous coat of the colon and probably arise in the same way, that is by the growing together of the villus-like projections of the surface of the mucosa.

The walls of the appendix and colon when compared are found to be similar except that the lymphoid tissue present in the appendix is absent in the colon and that the glands of the appendix are more rounded and consequently shorter in the appendix than in the colon.

When the wall of the appendix of man and that of the cat are compared the most striking difference is in the sub-mucosa. In man the lymphoid tissue forms definite rounded nodules which are disseparate and are embeded in the submucosa.

From the point of view of comparative anatomy the appearance in man, anthropoid apes, and a few other forms, of that vestigial organ, the vermiform appendix, is of high interest. In man it is not only apparently useless but is often the site of serious morbid changes.

As has been stated there is a marked correlation evident between the appendix and the caecum and between the caecum and diet. In carnivores where great reduction of the caecum has occurred the appendix has been stated to be absent.

According to the observations of Dexter on the cat, in stages earlier than the 24 mm. embryo certain portions of the digestive trace are extralimital to the abdominal cavity and are developed in the cavity of the umbilical cord which is continuous with the body coelom. The explanation of this fact is that at this stage in development the liver is of enormous size, and practically fills the body cavity, thus forcing the intestine to develop outside the coelom and in the cavity of the umbilical cord. After the 38 mm. stage these parts of the intestine leave the cavity of the umbilical cord and enter the coelom. This entrance takes place in a regular and definite order. It is of interest here to state that in the cat the caecum enters the body coelom early and in man it is the last part of the intestine to enter. This difference in the order of the entrance of the intestine is explicable, since in man the transverse colon is ventral to the small intestines and in the cat it is dorsal to them.

Whether or not the earlier migration of the caecum into the body cavity is a causal factor in the reduction of this organ and the absence of the appendix is not clear.

In the preparation of this paper I am greatly indebted to Professor James Nelson Gowanloch for his assistance and kindly criticism.

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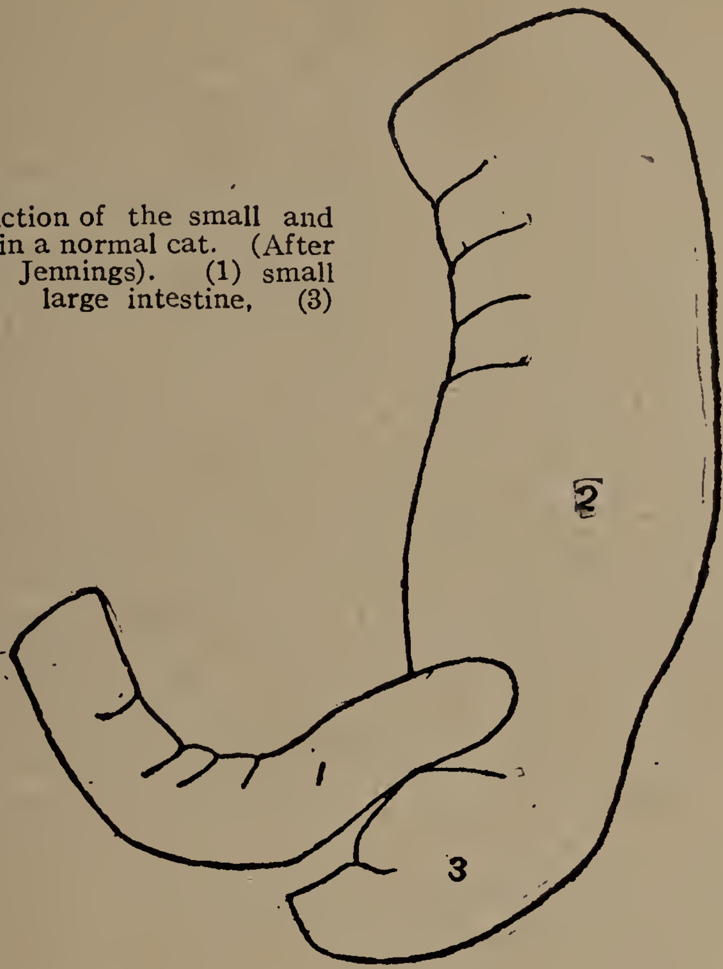

Fig. 1. Junction of the small and large intestine in a normal cat. (After Reighard and Jennings). (1) small intestine, (2) large intestine, (3) caecum.

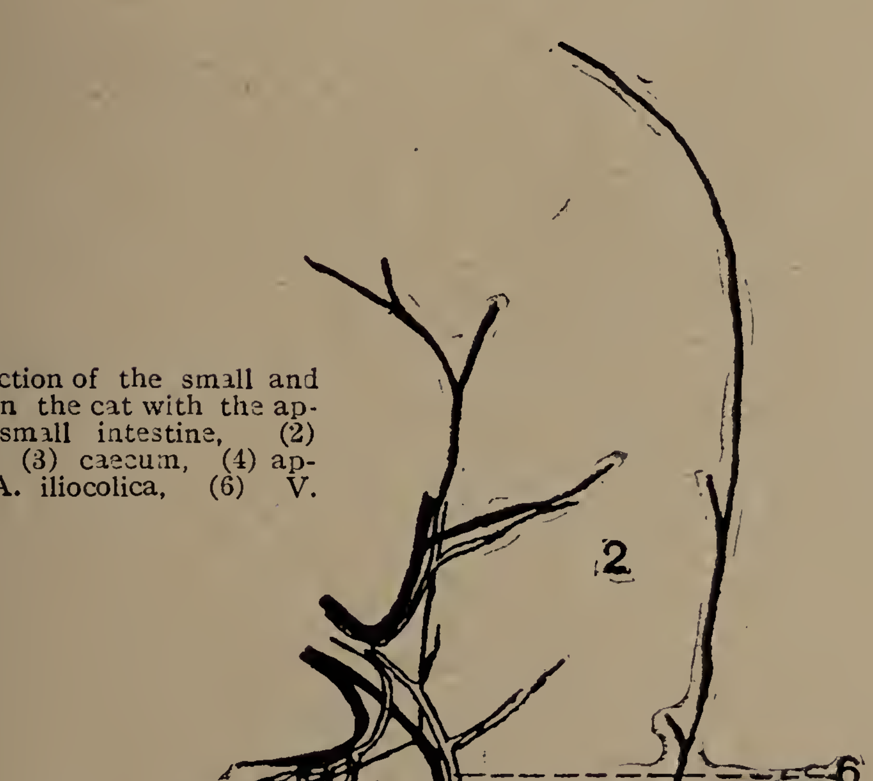

Fig. 2. Junction of the small and large intesting in the cat with the appendix. (1) small intestine, (2) large intestine, (3) caecum, (4) appendix, (5) A. iliocolica, (6) V. iliocolica.

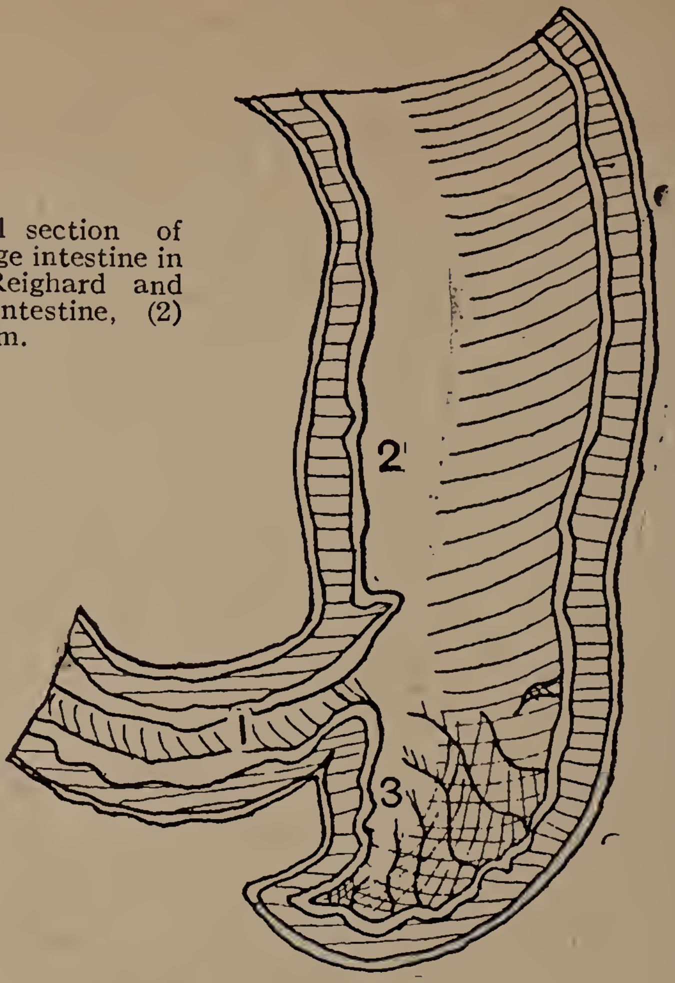

Fig. 3. Longitudinal section of junction of small and large intestine in normal cat. (After Reighard and Jennings). (1) small intestine, (2) large intestine, (3) caecum.

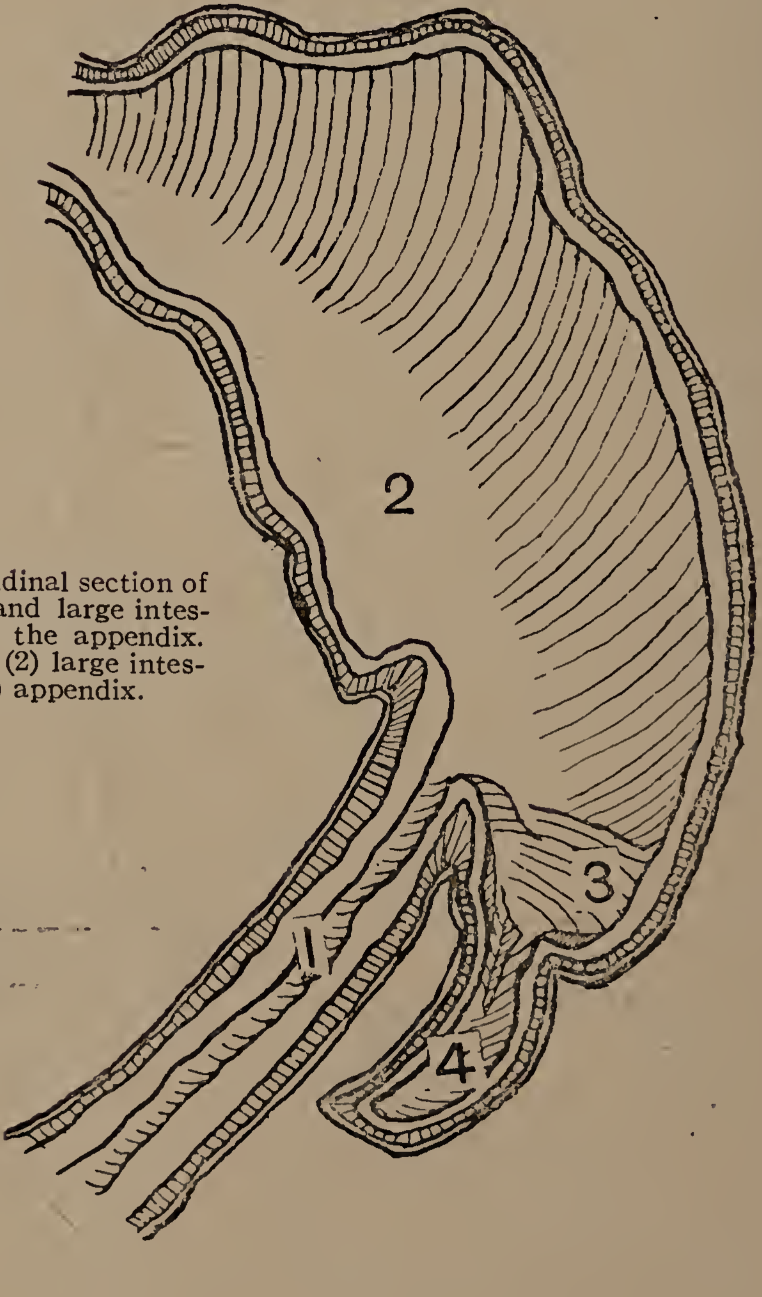

Fig. 4. Longitudinal section of junction of small and large intestine in the cat with the appendix. (1) small intestine, (2) large intestine, (2) caecum, (4) appendix.

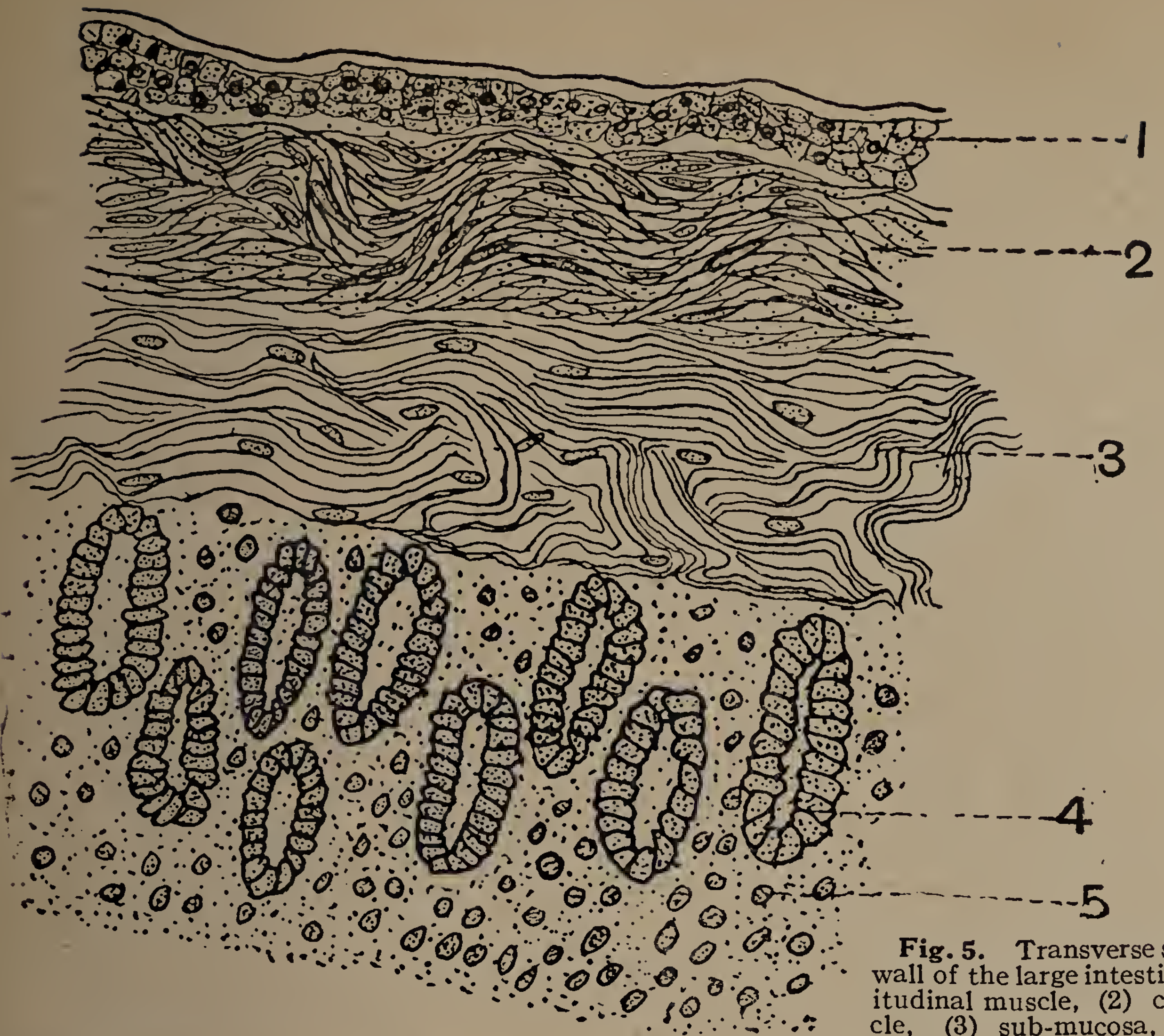

Fig. 5. Transverse section of the wall of the large intestine. (1) longitudinal muscle, (2) circular muscle, (3) sub-mucosa, (4) gland, (5) muscosa

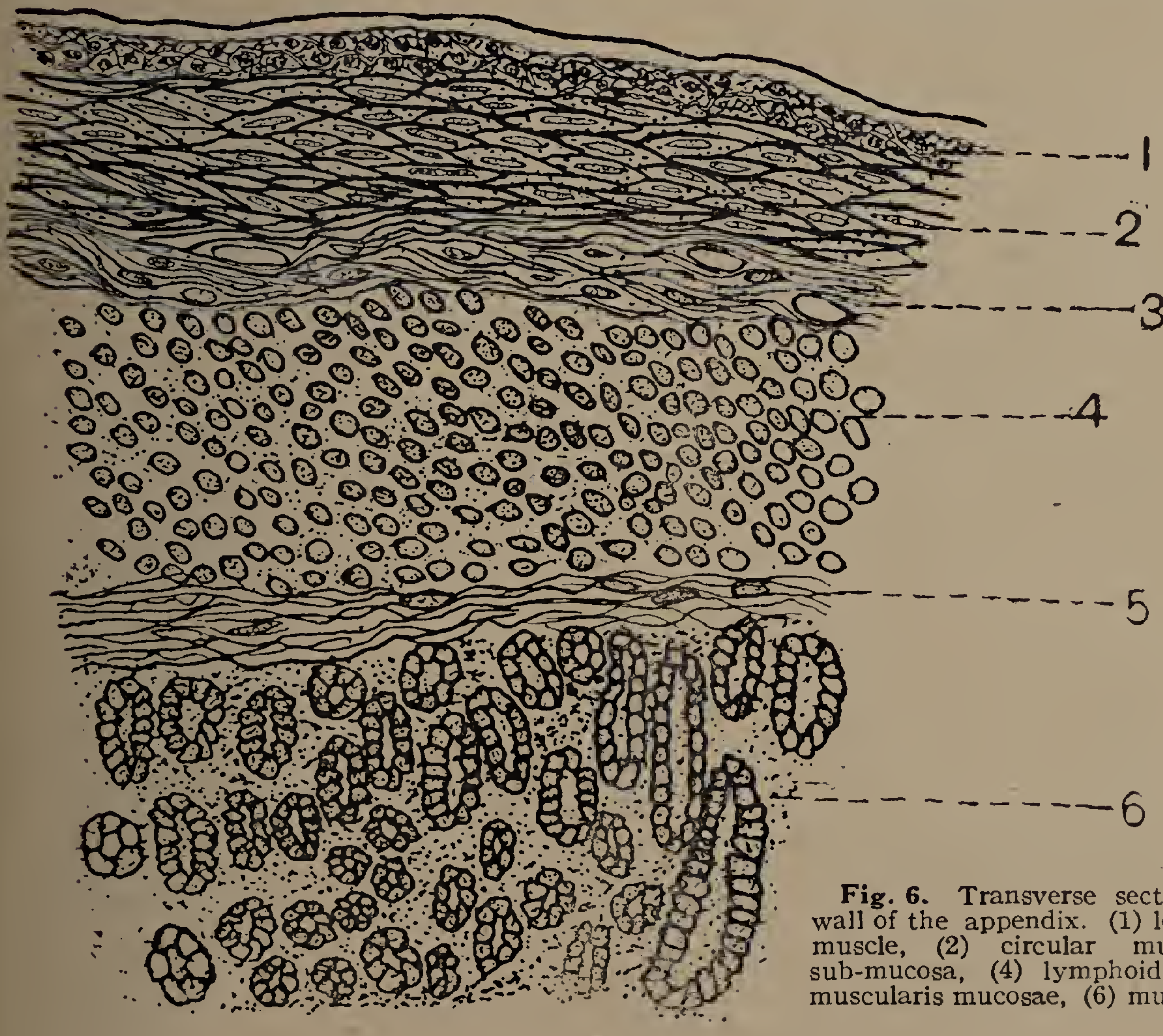

Fig. 6. Transverse section of the wall of the appendix. (1) longitudinal muscle, (2) circular muscle, (3) sub-mucosa, (4) lymphoid tissue, (5) muscularis mucosae, (6) mucosa.

OXYGEN-COMPOUND FORMATION WITH ACETALDEHYDE AT LOW TEMPERATURE.—A NOTE BY D. LEB. COOPER, M. SC., Chemistry Department, Dalhousie University, Halifax, N. S.

(Presented 19 March 1928)

Some evidence of the formation of a peroxide during the oxidation of acetaldehyde at low temperatures has been brought to my attention. The following experiment was designed with the object of gaining some information about the supposed reaction.

A small amount of acetaldehyde, together with finely powdered manganese acetate, was placed in the ordinary form of a bubbling tube which was kept immersed in a carbon dioxide-ether bath. Oxygen was circulated through this mixture by means of a Maass circulating pump. The oxygen was stored in a graduated cylinder, and admitted to the apparatus through a side arm on the bubbling tube, after having passed over phosphorus pentoxide, a tube of which was placed in series between the reservoir and the tube. During the circulation the storage system could be shut off by means of a series of stop cocks. An attempt was made to admit the oxygen directly into the pump, but this proved unsatisfactory owing to trappage of oxygen in the valve. Circulation with the tube empty and the apparatus arranged in the second manner showed that there was no trappage of oxygen.

Following are two typical experiments with acetaldehyde and the catalyst in the tube:

Time	Absorption cc.	Time	Absorption cc.
5.30	0	9.45	0
3.40	12	1.00	10
4.30	19	5.30	19
5.00	25	9.15	21
6.00	22	11.25	21

After the absorption the solution was a dark pink colour.

An analysis of the material thus treated was made with sodium hydroxide (N⁻.187) with the following results.

1. A test of freshly prepared acetaldehyde showed no trace of acid.

2. A run in which the following absorption occurred.

Time	Absorption cc.
10.30	0
12.30	7

gave the following results when titrated for acetic acid.

Calculated amount of HAc from titration (.0043 and .0044) mean .004 gm. A calculation shows an absorption of 7 cc. of oxygen is required for the formation of this amount of acetic acid from acetaldehyde.

In view of the fact that the absorbed oxygen reached a maximum in all runs that were allowed to continue for a period of over four hours, it is not improbable that this represents the solubility of oxygen in the acetaldehyde mixture, the oxidation power of the catalyst being absent at the low temperature of the experiment. On warming the solution it is possible that an immediate oxidation of acetaldehyde to acetic acid occured, which would account for the value found above.

The pink colour of the solution may indicate the formation of some complex. If this be the case the formation must be very slow, and the product formed must rearrange to acetic acid on warming to room temperature.

The experiment indicates therefore, that no peroxide stable at room temperature is formed..

The author wishes to express his thanks to the National Research Council, a bursary from which enabled this work to be carried out.

EXPERIMENTS WITH CAREFULLY DRIED SUBSTANCES.—BY D. McINTOSH, M.A., D.Sc., Dalhousie University, Halifax, N.S.

(Presented 9 April 1928)

The great catalytic effect of small amounts of water on chemical reactions is familiar to all students of chemistry. The principal worker in this field, Baker, has made during the last thirty years many surprising discoveries. Among these may be mentioned the inertness of very dry mixtures of hydrogen and oxygen, of dry oxygen to sulphur, phosphorus, etc., and in particular the high boiling-points of super-dried liquids, such as ether, benzene and mercury. It seems probable that the physical properties of all pure liquids are greatly altered by the removal of the last traces of water, and that constants, such as the boiling and freezing points, solubilities, etc., will need to be revised in the light of this new knowledge. It is not surprising then, that other investigators such as Smits and Cohen, have studied this interesting group of phenomena, and have made notable contributions to both the theoretical and experimental sides.

During the last few years I have made some few experiments with carefully dried materials, by employing low temperatures. These have yielded no positive results, but, by giving an account of the method, some one may be induced to try similar experiments, and to improve the technique. The lack of success is due probably to difficulty in removing the film of water from the glass surface, although the apparatus was strongly heated and kept at low pressure.

1. The union of carbon monoxide and oxygen.

A mixture of these gases in the proportion of two molecules of the former to one of the latter is not ignited by an electric spark if the gases are dried by freshly distilled phosphoric anhydride. They may be dried by cooling to a low temperature in the following simple way. The tube shown in Figure 1 is exhausted by a mechanical pump, the lower part of the tube is surrounded by carbon dioxide and ether in a Dewar flask, and the tube is filled with the gas mixture kept in a vessel over water. The upper part of the apparatus is always approximately at room temperature. Almost invariably the gases fail to explode after 15 hours, nearly always after 5 hours, and occasionally after only one hour's treatment.

When the apparatus is allowed to warm slowly in a Dewar vessel containing cold ether, the gas explodes when the outside temperature is between -50° and -60°. Since the vapour pressures of the water at these temperatures are 0.03 and 0.01 mm., there is only one molecule of water present to some 40,000 molecules of the gas.

The amount of water is not, however, the sole factor influencing this reaction, for the energy of the spark and the gas pressure have been found by Bone to affect the amount of water vapour necessary to bring about partial combustion. I might mention here that a detonating mixture of nitrous oxide and carbon monoxide is always exploded by a spark when dried by cooling at -80°. These experiments were made in September, 1921, and I was not aware until a short time ago that the same method of drying the carbon monoxide mixture had been used by **Girvan**[1] in 1902.

2. I have attempted to dry sodium sulphate so completely as to destroy all crystals, and thus render it inactive in precipitating crystals from a supersaturated solution. The apparatus was almost the same as that used in some former experiments and is shown in Figure 2. The super-saturated solution was placed in A, the apparatus was heated to destroy any crystals, and C was exhausted by a diffusion pump, sealed and allowed to stand for several weeks. C was then opened, and finely ground air-dried sulphate introduced by a gentle stream of filtered air, so that the particles must have been very small. C was re-exhausted and the apparatus allowed to stand for six weeks. Crystallization occurred instantly when the particles were introduced into the super-saturated solution.

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[1] Proc. Chem. Soc. 236.

The experiment was varied by using glass hairs[2], rubbed gently over a crystal of sodium sulphate, in the inner tube, and by attaching a side-tube, not shown in the sketch, containing phosphoric anhydride, or which could be placed in liquid air. The results were in all cases the same; precipitation took place at once.

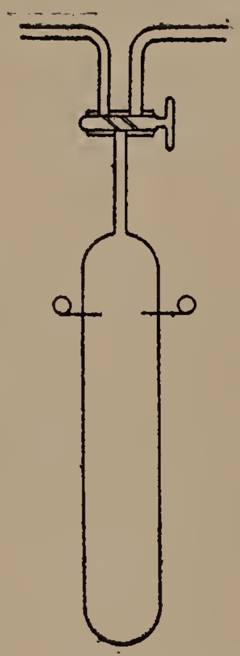

FIG. 1.

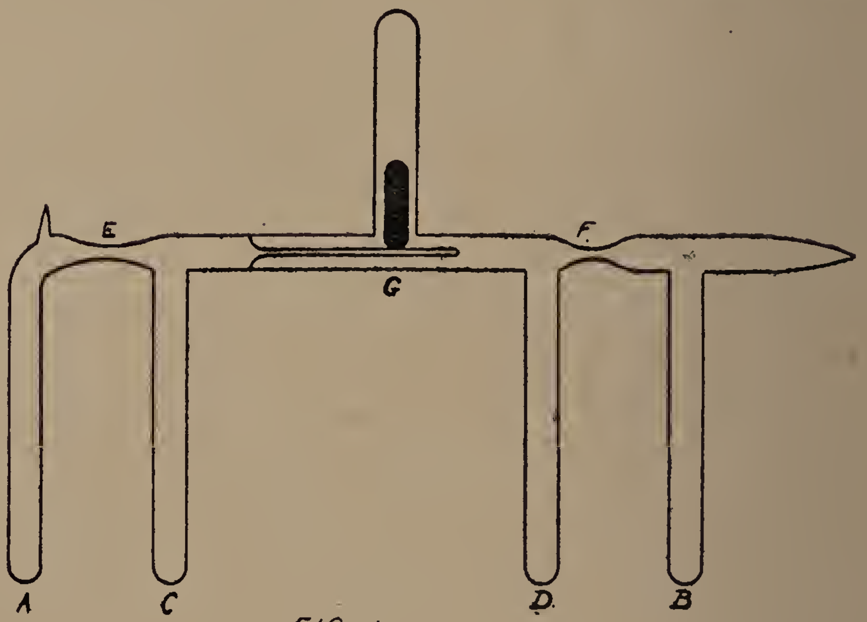

FIG 4

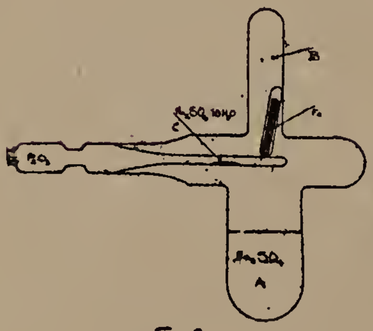

Fig 2.

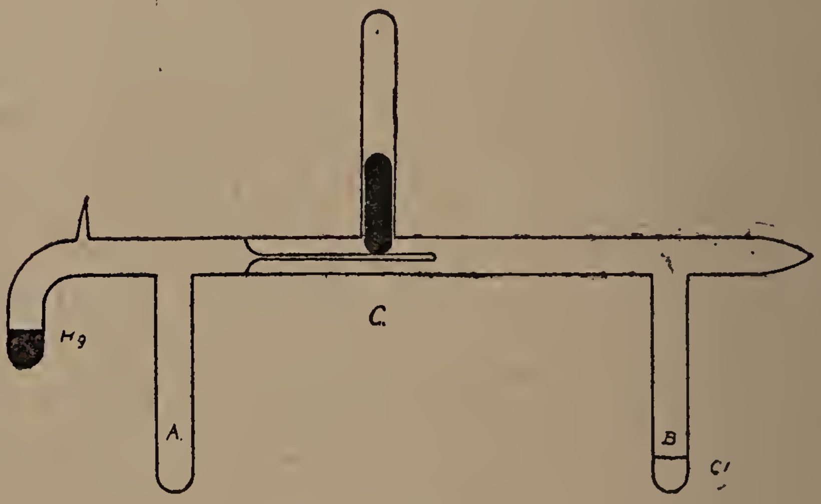

FIG 3

The precipitation may be due to the decahydrate or to anhydrous isomorphous crystals, as deCoppet suggested. In several experiments the tubes were heated to 45° for an hour.

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[2] Professor Gowanloch has kindly measured the size of some of these particles. They had a mass not greater than $3x10^{-8}$ gram.

After cooling no precipitation occurred when the salt was introduced. This indicates that the crystallization was due to the decahydrate, for it would be destroyed by the heat, while the anhydrous crystals would probably not be affected. Apparently the small crystals hold moisture very tenaciously, although the vapour pressure of the ordinary crystals is about 15 mm.

3. The interaction of mercury and chlorine has been examined repeatedly, and even with the most careful drying a reaction seems to take place[3]. I have made some experiments on this in the following way.

Mercury and chlorine were placed in the two side tubes of the apparatus shown in Figure 3. The side containing the mercury was exhausted with a diffusion pump and the mercury gently boiled. The tube containing the chlorine was frozen by liquid air and exhausted to a low pressure with a mechanical pump. Tubes A and B were cooled in liquid air for 24 hours, and the separating tube C, broken. At -180° the vapour presure of chlorine is quite appreciable, probably greater than 0.001 mm. At the low pressure of chlorine and water vapour there is no noticeable action on the droplets of mercury in 12 hours when they are examined with a magnifying glass. If the chlorine be allowed to rise in temperature, somewhere considerably below the temperature of solid carbon dioxide where the water vapour pressure is still very low, a reaction is evident.

4. The reaction between hydrobromic acid and ammonia.

The apparatus shown in Figure 4 was heated and exhausted. The end tubes were connected by rubber tubing to vessels containing liquid ammonia distilled from sodium, and hydrogen bromide respectively. The points were broken, so that the compounds distilled into A and B, which were cooled by liquid air. The apparatus was then exhausted and sealed. The acid and the ammonia were distilled into C and D at carbon dioxide temperature, and A and B were sealed off at E and F. C and D were kept at -80° for twenty-four hours. On breaking the

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[3] Germain, Jour. Phy. Chem. 28, 1218, 1924.

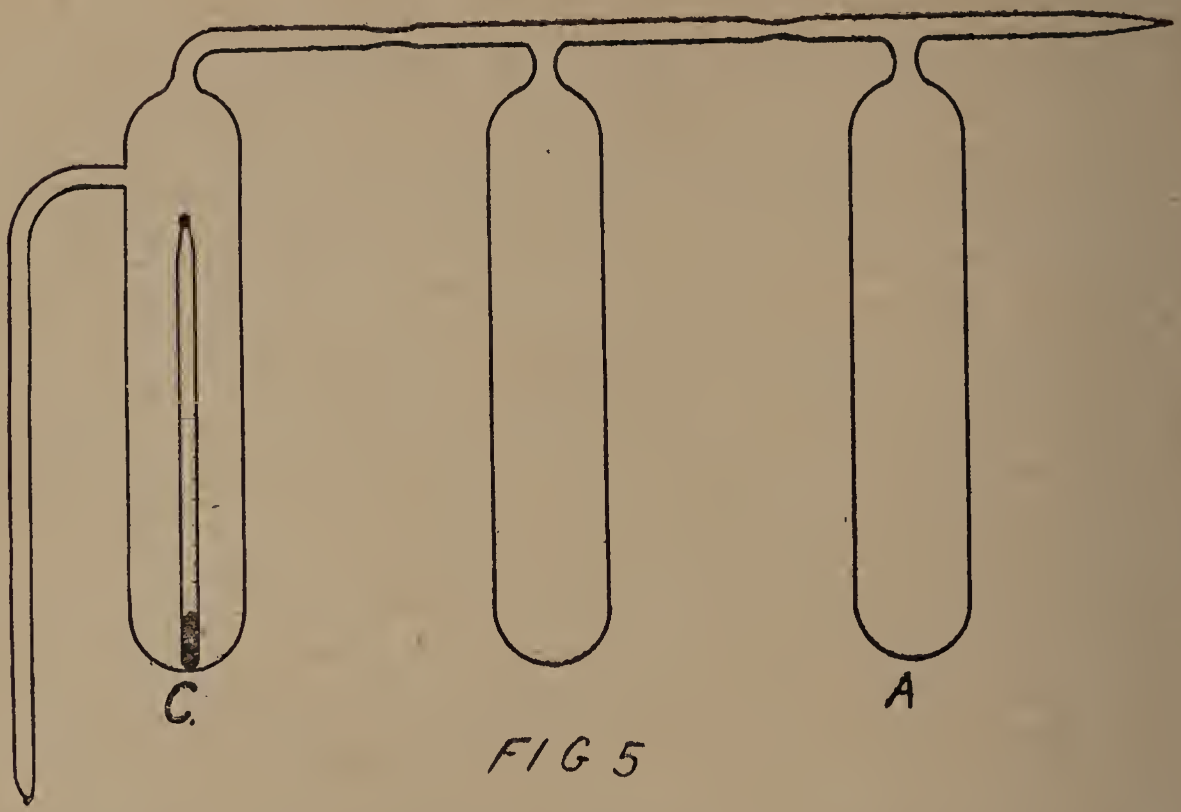
C.
A

FIG 5

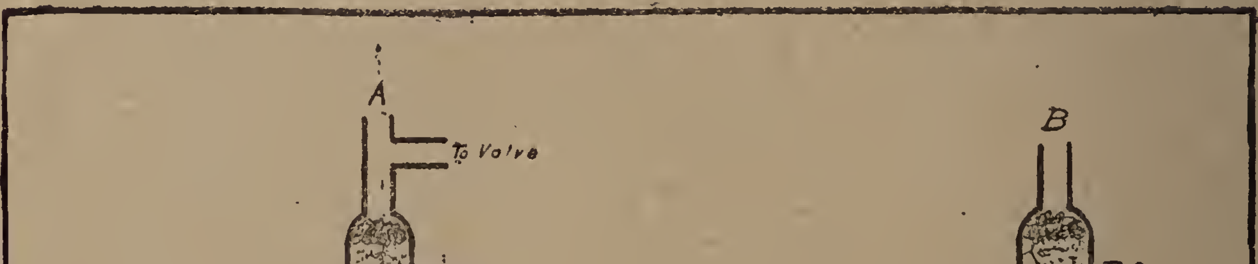
A
To Valve
B
P_2O_5
P_2O_5
G
D
E
H.
F.
L
I
Ether
Mercury
M
P_2O_5
K
Ether
P_2O_5
C.

Fig 6.

tube E, a cloud of ammonium bromide appeared, showing that the vapour-pressure of the water must be reduced below one one-thousandth of a millimeter to prevent interaction.

5. An attempt to dry ether.

In Baker's experiments the drying of ether was a matter of years. I have tried to make a high-boiling ether by distilling at a low temperature, since a comparison of the vapour-pressures curves of ether and water would seem to show that separation is more complete the lower the temperature.

The apparatus, shown in Figure 5, after remaining for some time exhausted to a low pressure, was filled with dry air. Ether, which had stood over sodium, was distilled into A, and the apparatus was exhausted and sealed. The ether was distilled at -80° into B and C, A and B being sealed off in turn. C was finally warmed in a water-bath to 36°, and the side tube was opened under freshly distilled mercury. The ether boiled at its normal temperature.

6. Drying ether by phosphoric anhydride.

This was done in the apparatus shown in Figure 6, which was constructed of Pyrex glass. It was exhausted by a diffusion pump for several hours being heated with a Bunsen burner to a high temperature, sealed and left for several weeks. The apparatus was opened at A and C, filled with dry air, phosphoric acid was distilled into E, and F sealed off. It was then re-exhausted through A, mercury distilled into the manometer, and the mercury bulb and phosphoric acid tube sealed off at H and G. The tube J, containing ether which had stood over sodium for several weeks, was then exhausted and the pentoxide tube sealed off at D. The valve connecting J with the main apparatus was broken, and the ether distilled at the temperature of solid carbonic acid into K, which was cooled with liquid air. The mercury in the manometer was frozen with carbon dioxide, the point of the manometer was broken, and ether introduced. This was boiled under reduced pressure until air was expelled, and the manometer was sealed. The apparatus, which is shown in the figure between the broken lines, was allowed to come to room temperature and the pressure read. The ether was then distilled slowly through the phosphoric anhydride tube by cooling M with tap-water After bringing to room temperature the manometer was read again, and this procedure was repeated each day.

Two experiments were made. In the first, a bubble or two of ether vapour passed from the manometer to M and the experiment was discontinued. The second trial seemed to be successful so far as the manipulation was concerned. The pressure however, equal at first on both sides of the manometer, increased on the dry ether side with each passage of the ether vapour through the phosphoric acid tube, and reached a difference of 5 centimeters at the 20th transference, and at the end of 6 months the oxide appeared quite moist. This increase of pressure may be due to decomposition of the ether into water and ethylene, which might possibly take place with ether not sufficiently dried in the beginning, or from water liberated from the glass when making the necessary seals.

The attention of members of the Institute presenting communications for publication is directed to the following notes.

1. Eighty "separates" of each communication accepted by the Council for publication are provided for the author.

2. Drawings which have to be reduced in size should have the lines and letters sufficiently large to be distinctly visible in the print. The drawings should be about double the size of the proposed print. The copy should be carefully typed or in distinct manuscript.

3. The nomenclature of species, etc., should be given in good form, such as is recommended by the authorities directing the abstracting of scientific literature.

4. References to previous or other papers should be made clearly and neatly in the forms approved as in 3.

5. The titles of papers communicated should be made as brief as possible while expressing its subject as definitely as desirable.

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THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

VOLUME XVII

PART 3

SESSION 1928-1929

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TRANSACTIONS

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THE HEATS OF SOLUTION OF CERTAIN ALKALI HALIDES AND THE SPECIFIC HEAT OF THEIR SOLUTIONS.—By H. RITCHIE CHIPMAN, PH.D., F.C.I.C.; F. M. G. JOHNSON, PH. D. F.R.S.C.; and OTTO MAASS, PH.D., F.R.S.C.

(Presented 14 January 1929)

ABSTRACT.

A new form of apparatus for the determination of the heat of solution is described. This determination requires the specific heats of the salt solutions and values have been obtained by a new method. The salts investigated were sodium chloride, sodium bromide, potassium chloride, and potassium bromide.

The heat of solution of the above mentioned salts have been determined over a concentration range. With sodium bromide it was found that the sign of the value changed at a certain concentration. With the potassium salts a temperature coefficient was found and this coefficient was found to vary with concentration.

The values obtained for the heats of solution of the salts and also for the specific heats of their solutions are shown in suitable figures, and a short discussion is given.

The heats of solution of a large number of salts have been determined, but most of the experimental data were obtained before the introduction of the adiabatic calorimeter and did not extend over a large concentration range. It was therefore decided to determine the relation between the heats of solution of some of the alkali halides and their concentration. This work was carried out in 1925, at McGill University, Montreal.

In many of the earlier forms of apparatus it was impossible to prevent heat losses. In measuring the heat of solution, a weighed quantity of salt is dissolved in a weighed quantity of water and the change in temperature measured. The salt and the water must be at the same temperature before mixing, and, when mixing occurs, it must be complete and the solution well stirred. The measurement of the temperature change is of great importance. Mercury or resistance thermometers possess too large a heat capacity, and a thermocouple used as a an absolute instrument is inconvenient. The method chosen for this work was to use a thermocouple as a null-point instrument,one junction being in contact with the reactants while the temperature of the other is measured by a resistance thermometer.

In previous forms of apparatus the design adopted to insure correct temperature equilibrium of the reactants and their complete mixing required a relatively large amount of material, which was a drawback when working with salts of which only a small quantity is available or when using low concentrations. In these determinations an apparatus has been designed to enable the reactants to be kept at the same temperature and allow the reaction to take place when desired. Very small quantities of salt may be used and as little as thirty cubic centimeters of liquid.

The substances investigated were sodium chloride, sodium bromide, potassium chloride and potassium bromide. All salts were of c. p. quality, recrystallized from distilled water, and the crystals pulverised in an agate mortar. All glass vessels used were Pyrex.

In determining the heats of solution it is necessary to know the specific heat of the salt solution over the concentration range employed. Several values for the specific heat of solutions are available in the literature but they were somewhat uncertain on account of the concentration at which they were determined. It was therfore decided to determine the specific heats of the solutions by a new method and at more suitable temperatures.

The usual method of determining specific heats is to add a definite amount of heat and observe the resulting change in temperature. An accurate knowledge of the heat capacities of the parts of the apparatus is required and many errors from heat losses are encountered. The new method is a relative one, water is taken as the standard and the errors due to heat losses are compensated. A definite amount of heat is taken from the solution and the temperature change measured. A quantity of distiled water is placed in a small container, frozen, and kept in a bath at a constant low temperature. This container is then placed in water in an adiabatic calorimeter and the drop in the temperature of the calorimeter measured. Heat will be absorbed by the melting of the ice in the container and by raising it and its contents to the temperature of the water in the calorimeter. The largest portion of heat will be absorbed by the melting of the ice, and as the same amount of water is sealed up in the container, this is always a constant quantity. The use of this container thus permits the abstraction of a constant amount of heat from the water in the calorimeter.

Having measured the drop in temperature produced when the container is placed in the water, and knowing the weights of the water and the calorimetric vessels,together with their specific heats, an equation may be obtained relating the drop in temperature to the number of calories taken up by the water in the container. This process is then repeated, using a salt solution in place of water in the calorimeter, whereupon a similar equation is obtained containing the specific heat of the solution as an unkown.

As the container always takes the same amount of heat from the solution, being at the same initial temperature in all cases,the number of calories absorbed by the water will be the same as the number absorbed by the salt solution, the different drop in temperature being caused by the difference between the specific heat of the water and that of the salt solution. From these relations the specific heat of the salt solution may be obtained. By the use of this method any heat losses existing as constant errors are compensated, as the value for the number of calories absorbed are obtained by the same experimental procedure.

The small container consisted of a copper cylinder about 7 cms in length closed by a copper tube with a cap. The cylinder was filled with distilled water and the cap soldered on. The tightness of the cylinder was tested by allowing it to remain in a vacuum for some time. No loss in weight was found.

The initial bath for the container was a porcelain beaker containing salt solution and ice. The solution was well stirred with a paddle. The container was kept in the bath in a copper tube which it fitted tightly. The temperature of the bath was measured by a Beckmann thermometer and a temperature which was about –4.6°C was chosen and was held to within 0.1°C. The container was allowed to remain in this bath for one and one half hours.

The adiabatic calorimeter was essentially the same apparatus as used by Maass and Waldbauer[1] in their determination of specific and latent heats. The calorimeter vessel was of copper and held about 1300 cc. It was well insulated from its containing vessel. The liquid in the calorimeter was stirred by an up-and-down stirrer. The outer bath was stirred by paddles.

The temperature of the outer bath was measured by a Beckmann thermometer calibrated by the Bureau of Standards. The balancing of the calorimeter was done by a copper-constantin thermocouple which was directly connected to a sensitive galvanometer. One junction of the couple dipped into the calorimeter and the other into the outer bath. When a thermal balance was obtained the temperature of the calorimeter could be read by the Beckmann thermometer. The two baths could easily be kept to within 0.001° of each other.

The solution was made up to the desired strength by weighing the salt and the water. It was then brought to a temperature which was found by experiment to be the one most suitable for a convenient initial temperature when the calorimeter was balanced, and was weighed into the calorimeter.

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[1] **Maass & Waldbauer.** J. A. C. S., **42**, 1, (1925).

The apparatus was then assembled and the bath balanced when readings constant to 0.002° were recorded every five minutes for fifteen minutes. After a balance was obtained the container was introduced into the calorimeter. The resulting temperature change was followed by the addition of cold water and the baths finally balanced once more. The temperature interval could then be obtained.

Knowing the weights of the vessels and their specific heats, the number of calories given up by the water could be calculated. The same procedure was repeated using a salt solution in the calorimeter. The specific heat of the solution was an unknown in the resulting equation obtained by equating the number of calories given up by the solution to the number given up by the water.

The specific heats of solutions of the salts investigated were measured over a concentration range from 0.2 to 4.0 molar, and the following results obtained:

TABLE I.

SPECIFIC HEATS OF SALT SOLUTIONS.

Sodium Chloride

Concentration	Specific Heat
0.423	0.9648
0.839	0.9353
1.650	0.8967
2.435	0.8680

Sodium Bromide

Concentration	Specific Heat
0.241	0.9695
0.479	0.9381
0.946	0.8922
1.312	0.8643
1.833	0.8261

Potassium Chloride

Concentration	Specific Heat
0.331	0.9651
0.653	0.9362
1.290	0.8829
1.898	0.8408
2.476	0.8057

Potassium Bromide

Concentration	Specific Heat
0.208	0.9638
0.412	0.9361
0.632	0.9079
0.803	0.8916
0.969	0.8708
1.199	0.8433
1.568	0.8107

These results are shown in Fig. I.

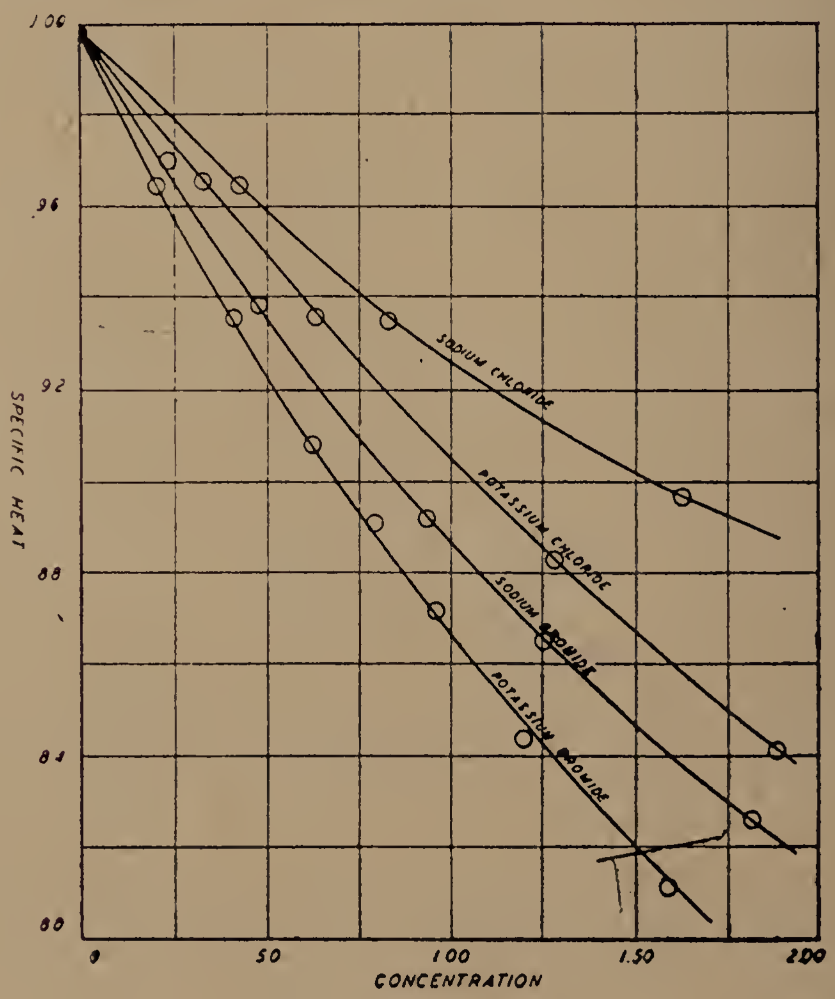

FIG. I

The average temperature at which the preceeding determinations were carried out was 25.4°C. It was decided to carry out a few experiments with the same solutions at a lower temperature to see if there was an appreciable difference. The lower temperature was 18.8°C. The values found at the higher temperature are given for comparison.

TABLE II.

EFFECT OF TEMPERATURE OF SPECIFIC HEATS.

Salt	Concentration	S. H. 18.8°	S. H. 25.4°
Sodium chloride	1.79	0.8964	0.8930
	2.44	0.8664	0.8680
Sodium bromide	1.13	0.9962	0.8775
	1.40	0.8700	0.8575
Potassium chloride	1.57	0.8751	0.8563
Potassium bromide	1.20	0.8509	0.8433

It will be seen from Table II. that a change in the specific heat is shown with change in temperature. This variation seems to be more marked with potassium salts than with sodium.

Having obtained values for the specific heats of the salt solution, the determination of the heats of solution were carried out.

The apparatus consisted of an adiabatic calorimeter where the calorimeter proper consisted of a small silver vessel so designed that salt could be held in it and water admitted at will. The small vessel is shown in detail in Fig.2.

The only openings in the vessel were the tube at the top and the openings at the bottom which were shielded by a system of vanes. Owing to the arrangement of the bottom openings no water could enter the vessel unless the air could escape from the tube at the top. The entrance of the water could then be controlled by air pressure which was regulated by the pump as shown in Fig. 2.

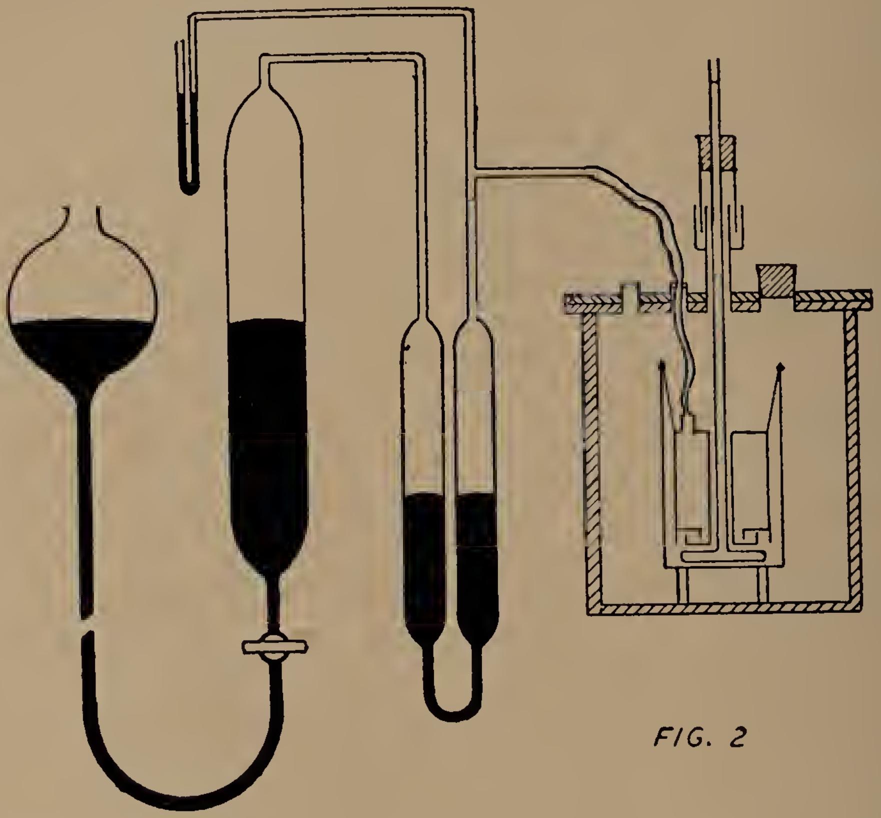

FIG. 2

The vessel containing the salt was fastened concentrically within another silver vessel, sufficient space being left at the bottom for a stirrer, and at the sides for the thermocouple. This vessel was in turn placed in a brass vessel which was immersed in the outer bath of the calorimeter. The silver vessel was insulated from the brass vessel by small glass legs. The brass vessel was closed by a brass plate having suitable holes for the tubes and stirrer. This plate was well greased before fitting and was held in place by means of three clamps The liquid in the inner vessel was stirred by a small glass stirrer which passed through the tube in the center. This stirrer was driven by a small motor and the hole by which it passed through the brass cover of the outer vessel was closed by a rotating mercury seal, in order to prevent leakage of air at this point. When air was pumped in or out of the inner vessel it could only come in or go out of the brass vessel by means of a tube which was connected with a series of bulbs which were kept below the surface of the water in the outer bath. By this means the air was always at the same temperature as the rest of the apparatus.

It will be seen from Fig. 2. that the pump is so arranged that the air which is pumped in and out of the inner vessel comes from a cylinder which is below the surface of the outer bath and hence always at the same temperature as the inner vessel.

The connection between the inner vessel and the pumping system was made by a small rubber tube. This tube was made from a small surgical catheter. It was fastened at one end to a small silver plug which tightly fitted into the tube at the top of the inner vessel, and the other end was fastened to a tapering glass tube which passed through the cover of the brass vessel. An ordinary rubber tube connected this glass tube to the pump tubing. In assembling the apparatus the tapering glass tube was passed through the cover of the brass vessel and was cemented in place by deKhotinsky cement. After the cement had hardened the rubber connection could be made to the pump system.

A manometer placed in the pump system was so calibrated as to show the level of the water in the inner vessel. It will thus be seen that the salt and the water may be kept at the same temperature for any length of time. By manipulation of the pump the water may be admitted to the salt, and solution will occur. By pumping the solution in and out of the inner vessel thorough mixing takes place, and all the salt is dissolved. All the reactants and the air with which they come into contact are at the same temperature before mixing.

The thermocouple was a single junction of copper and constantin and led to a sensitive galvanometer. One junction of the couple dipped into the water in the inner vessel and the other dipped into the water in the outer bath. The calorimetric was balanced in the same way as was the one used for the specific heat work, except that the temperature of the outer bath was read by means of a resistance thermometer.

In making a determination a weighed amount of salt was introduced into the inner vessel and the apparatus put together. A known weight of water was introduced into the inner vessel by means of a weight pipette: the air pressure within the small vessel preventing the water from reaching the salt. The baths were then balanced and temperature readings taken every five minutes. It was found that a constant temperature was not obtained but there was a steady decrease. To obtain a correct initial temperature the readings were plotted against time in minutes and the curve extrapolated to the time at which the reaction took place. This procedure was also necessary at the end of the reaction.

After sufficient readings had been taken to allow exact extrapolation, the pump was started and the water allowed to enter the vessel containing the salt. There was immediately a change of temperature and the baths were kept balanced during the solution. The solution was pumped in and out of the inner vessel to ensure sufficient solution and mixing, until there was no further change in temperature.

Knowing the weights of the calorimeters, the salt, and the water, and having obtained the temperature change, the heat of solution could then be calculated.

The following results were obtained with sodium chloride. With this salt it was found inadvisable to use concentrations less than 0.2 molar as the heat change was so slight that the errors produced a larger effect.

TABLE III.

HEAT OF SOLUTION OF SODIUM CHLORIDE.

Concentration	Heat of solution per gram mol.	Average
0.202 molar	1199 calories	
0.202	1198	
0.202	1181	1193
0.404	1173	
0.404	1159	
0.404	1142	
0.404	1161	1159
0.604	1004	
0.604	1049	
0.644	997	
0.644	1043	1023
0.821	994	
0.821	1026	
0.821	1004	
0.821	1017	1010
1.23	917	
1.23	918	918
1.63	832	
1.63	841	836
2.12	753	
2.12	757	755
2.62	702	
2.62	679	
2.62	691	686
3.18	555	
3.18	566	560
4.03	478	
4.03	475	477

These results are shown in Fig. 3.

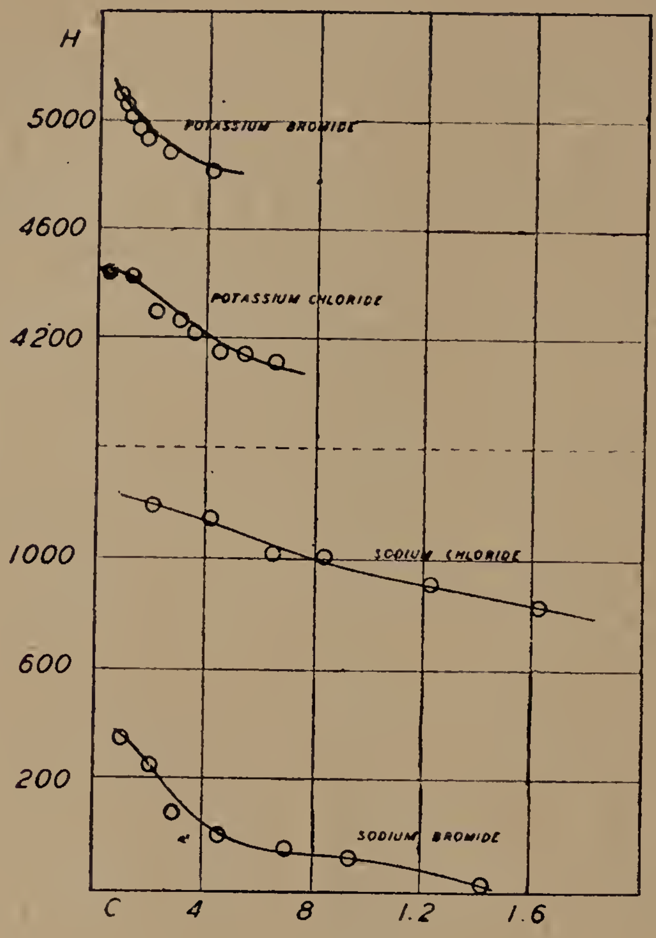

FIG 3

Sodium bromide forms a dihydrate and a pentahydrate. The transition point of the anhydrous salt and the dihydrate is about 50.7° while that of the pentahydrate and ice is about −27°. The sodium bromide was carefully dehydrated and it was found that the salt would remain long enough in the anhydrous condition to allow a determination of the heat of solution to be made.

The same procedure was used as with sodium chloride. At lower concentrations a similiar effect was obtained but the heat of solution was much smaller. At a concentration of about 0.5 molar no temperature change was observed. With higher concentrations a positive value was obtained due to the effect of the formation of the hydrate. Evidence points to the fact that the dihydrate is first formed and then this goes into solution. This was shown by the fact that when the salt was first dissolved heat was evolved and after a time heat was suddenly absorbed. Large concentrations could not be used on account of the large amount of heat evolved and then absorbed. The results are shown in Table IV.

TABLE IV.

HEAT OF SOLUTION OF SODIUN BROMIDE.

Concentration	Heat change per gm. mol.	Average
0.106 molar	— 324 cals	
0.106	— 355	
0.106	— 378	— 352
0.203	— 259	
0.203	— 260	— 260
0.297	— 86	
0.297	— 98	— 92
0.486	— 17	
0.486	+ 17	0
0.705	+ 38	
0.705	+ 35	+ 36
0.945	+ 75	
0.945	+ 72	+ 72
1.41	+ 187	
1.41	+ 192	+ 190

These values are shown in Fig. 3.

Attempts were made to prepare sodium bromide dihydrate, but a stable hydrate could not be obtained.

It was found that the potassium salts possessed a temperaure coefficient which apparantly varied with the concentration. A different procedure was then followed for the potassium salts. Determinations were made at the same concentrations but at different temperatures, the temperature being taken as the mean between the initial and final temperatures. The results were then plotted against temperature. The relation between the heat of solution and temperature is linear and a series of straight lines were drawn through points of the same concentration. The temperature coefficient would be the slope of these lines, which would be parallel if the coefficient is independent of the concentration. It was found that such was not the case. As the heats of solution had been determined at a temperature of about 22° the values for the heats of solution of the potassium salts were taken from the ordinate of 22° and are shown in Fig. 3. The results obtained for potassium chloride are given in Table V.

TABLE V.

HEAT OF SOLUTION OF POTASSIUM CHLORIDE.

Concentration	Heat absorbed per gm. mol	Average Temperature
0.067 molar	4495 calories	23.1°
0.067	4411	22.6°
0.067	4335	23.6°
0.133	4412	22.5°
0.133	4442	21.6°
0.133	4540	16.1°
0.133	4353	26.8°
0.133	4315	27.6°
0.224	4316	21.0°
0.224	4459	19.4°
0.271	4304	22.6°
0.271	4283	22.6°
0.271	4468	21.0°
0.313	4411	17.6°
0.313	4441	17.2°
0.313	4280	21.6°
0.351	4255	21.3°
0.390	4230	21.9°
0.390	4253	20.7°
0.390	4253	20.6°
0.438	3986	26.7°
0.438	3973	28.6°
0.438	4402	15.8°
0.438	4141	22.0°
0.438	4282	18.0°
0.528	4181	22.0°
0.528	4332	18.3°
0.656	4105	22.5°
0.656	4123	22.8°
0.656	4424	14.2°
0.656	4036	25.6°

It was difficult to work with greater concentrations of potassium chloride than 0.7 molar account of the large heat changes which took place.

With potassium bromide a temperature coefficient was also found and the same procedure was followed. The results are in Table VI.

Table VI.

HEAT OF SOLUTION OF POTASSIUM BROMIDE.

Concentration	Heat absorbed per gm. mol.	Average temperature
0.090 molar	5148 calories	16.5°
0.090	5128	15.5°
0.090	4992	25.6°
0.090	5000	26.3°
0.090	4952	27.0°
0.090	4811	26.3°
0.106	4879	26.1°
0.110	4783	26.2°
0.110	4693	26.3°
0.110	4694	27.2°
0.110	4789	27.3°
0.130	4735	27.2°
0.130	4742	26.3°
0.170	5095	15.7°
0.170	5138	16.1°
0.170	4601	26.8°
0.170	4688	26.3°
0.170	5046	15.9°
0.170	4685	25.7°
0.170	5049	16.4°
0.250	5132	14.7°
0.250	5056	15.6°
0.250	4759	23.5°
0.250	4627	26.2°
0.250	5109	17.0°
0.420	4573	26.3°
0.420	4557	26.6°
0.420	4936	17.2°
0.420	5019	15.1°

The results obtained for potassium salts showed not only a temperature coefficient but a change in that coefficient with temperature. The temperature coefficient plotted against temperature is shown in Fig. 4. It will be noticed that here is a tendency for the coefficient to approach a constant value; but in the case of potassium bromide this is reached more quickly.

A qualitative explanation for the general shape of the heat of solutions curves may be obtained by the use of two thermochemical magnitudes introduced by Born[2] and Fajans[3]: "the lattice energy of crystals" and the "heat of hydration of gas ions".

Since the ions in the space lattice of a crystal maintain their relative positions as is shown by the stability of the crystal, there must be forces of attraction which result in the structure of the crystal. When the crystal goes into solution the ions leave their places in the space lattice and move about in the solvent. Energy must be supplied to overcome the forces of attraction, and, according to Born, the energy necessary for the formation of free gaseous ions from crystals is defined as the lattice energy. Born has calculated the magnitude of this energy for a number of crystals from a knowledge of their molecular volumes.

It would be expected that changes of energy would be found when the ions associate themselves with solvent molecules, and to express these energy changes due to hydration Fajans employes the term, "heat of hydration of gas ions." According to Fajans the heat of solution of a salt in water is dependent upon the amount of heat evolved by the dissociation of the salt into ions, and the amount of heat developed by the solution of these ions in water. Butler[4] relates the solubility of a salt to its heat of solution, heat of hydration of ions and lattice energy. The solubilities of the salts are not proportional to their lattice energy and no doubt there are other factors governed by the heat of hydration.

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[2] **Born.** Ber. Deut. Phys. Ges., **21**, 13, (1919).
[3] **Fajans.** Ber. Deut. Phys. Ges., **21**, 549, (1919).
[4] **Butler.** Zeit. Phys. Chem., **113**, 285, (1924).
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As the lattice energy is a magnitude which relates solely to the ions of the salt as they exist in their position in the space lattice, and not to their condition in solution, it is not affected by changes in concentration. It may be considered as a constant, although it may be influenced by temperature. If the lattice energy is a constant, variations in the heats of solution will depend upon the heats of hydration of the ions.

The curves for the heats of solution show a decrease with increasing concentration and the rate of decrease becomes less at the higher concentrations. At low concentrations the ionization approaches its maxium value and a large number of ions are present giving a larger value for the heat of hydration of these ions. If the concentrations be increased the ionization decreases and the number of ions decrease, the heat of hydration becomes less and the heats of solution are smaller.

Let us consider the temperature coefficient which was found with potassium salts and which is shown in Fig. IV. We may perform a cycle with the same masses as follows. We may allow the reaction to proceed at T_1 and heat the resulting solution to T_2, then we may allow the reaction to proceed in the reverse order at T_2 and cool down the products to T_1. In this cycle the sum of the heat changes will be zero. In the formation of one gram of solution at T_1 we have an absorption of heat H_1 and heating up the resulting solution to T_2 requires a further absorption of heat, $S(T_2-T_1)$ where S is the average specific heat of the solution between T_1 and T_2. Allowing the reaction to proceed in the reverse way at T_2 with an evolution of heat H_2 and then cooling down the products to T_1, we have a further evolution of heat, $(m_1S' + m_2)(T_2 - T_1)$ where m_1 is the weight of salt required to form one gram of solution at the concentration chosen, S' being its specific heat: m_2 is the weight of the water, its specific heat being taken as unity. Equating the heat changes to zero we obtain the well known equation,

$$\frac{H_1 - H_2}{T_2 - T_1} = m_1S' + m_2 - S$$

$$\text{or} \quad dH/dT = m_1S' + m_2 - S$$

If actual values are inserted into this equation good agreement is found with the potassium salts where a temperature coefficient was found to exist. A consideration of this equation gives an explanation of the slopes of the curves showing the change in dH/dT with change in concentration as shown in Fig. 4.

As infinite dilution is approached, the term m_1S becomes less and at zero concentration it vanishes, there being left the two terms m_2 and S. As m_1 is diminished m_2 increases and approaches the limit of unity. At this limit there is nothing but water present and the terms m_2 and S_2 being equal, dH/dT is zero. It will be seen from Fig. 4. that the curves approach zero with zero concentration.

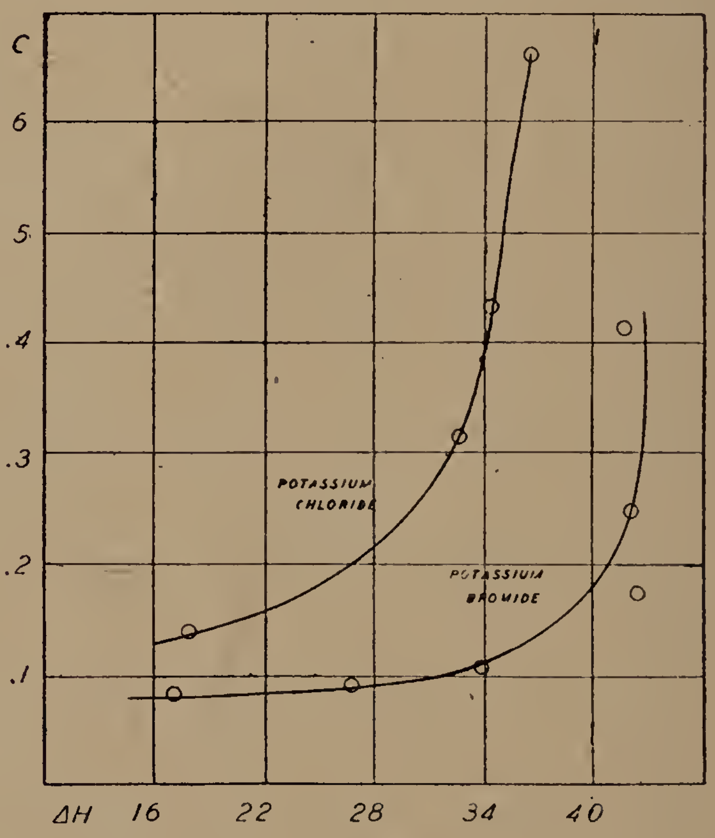

FIG 4

As the concentration is increased the term m_1S' increases and m_2 decreases. At the limit m_2 is zero. Therefore a limiting value is reached which is not the same in the case of different salts on account of the difference in the specific heats. Where there is no change in the heat of solution with temperature the left hand side of the equation will be zero and hence the right hand side will be zero.

The relation between the heat of hydration of the ions and the heat of solution has been pointed out, and it may be seen that a decrease in the extent of hydration results in a decrease in the heat of solution. It is known that an increase in temperature decreases the amount of hydration and hence it should produce a decrease in the heat of solution. Where a change in the heat of solution has been found the heat of solution does decrease with rising temperature as would be expected.

It has been mentioned that changes in the lattice energy would be expected with changes in temperature. The vibrational energy of the ions in the lattice would be increased with rising temperature and this would doubtless have an appreciable effect on the amount of energy required to remove them from their positions in the lattice. Therefore in discussing the effect of temperature upon heat of solution its effect upon lattice energy and heat of hydration must be considered. This is so complex that a suitable discussion cannot be attempted at the present time.

Grateful acknowledgement is made to the National Research Council of Canada for a Studentship held by one of us during the progress of this work, and also for a grant which made it possible to carry it out.

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THE EFFECT OF VELOCITY ON DIFFUSION RATES.—By A. E. MURRAY, B.A., Pharmacological Department, Dalhousie University, Halifax, N. S.

(Presented 14 November 1928)

ABSTRACT.

Experiments have been conducted by placing salt solutions in colloidin thimbles and allowing them to diffuse into distilled water which was either circulated or being constantly replaced.

Under such conditions there is a rapid development of a small osmotic pressure which was measured directly by a capilliary tube reading. This rise, usually complete in 60-90 minutes, was shown to be influenced by a velocity of the diffusate, though not proportionally in the case of NaCl. A rough relation was found in the case of 1% disodium phosphate.

Introduction: It is generally conceded that if a salt diffuses readily through a permeable membrane that its osmotic effect from a physiological point of view is negligible. Indeed with such authors as Bayliss[1] or Burns[2] the question of temporary osmotic pressure, such as is developed by sodium chloride diffusing against distilled water through colloidin membranes, is not mentioned; also in the filtration part of renal function it is assumed that the only effective osmotic of the blood is that due to the colloids. If however the pressure of blood be directly measured by means of colloidin filters then it is necessary to wait twenty-four hours until an equilibrium be obtained owing to the salts effecting a temporary osmotic pressure.

In view of these facts it appears possible that the diffusible salts might play an important osmotic role in the body since the circulation may either prevent a diffusion equilibrium from becoming completed by removing a substance faster than it diffused, or by itself creating disequilibrium. In such places where rapid metabolic breakdown was occurring this especially appears possible.

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[1] Bayliss, W. M., Principles of General Physiology, Longmans, Green & Co.

[2] Burns, D., An Introduction to Biophysics, J. & A. Churchill.

Experiments have therefore been conducted to ascertain if velocity will effect changes in the osmotic pressure rise of various salts diffused into distilled water. These experiments roughly consisted of placing a salt solution in a colloidin thimble which is surrounded by distilled water, the osmotic pressure rise being measured directly by the column developed in a capillary tube. Arrangements were made either to circulate the fluid past the membrane or to pass a continuous stream of fresh water over the membrane.

Preliminary experiments were carried out with a motor driven pump giving a varying circulation rate of 400 to 2000 cc per minute. The flow was recorded by a venturiometer, which of course required calibration. Various speeds at room temperature were employed, using a total volume of 100 cc. of circulating fluid (distilled water) against 5 cc. of 1% NaCl. Compared to zero reading—see Table I below—it was clear that moving the fluid increased the height of pressure rise, but all the velocities used seemed to have approximately the same effect.

These results suggested that the circulatory rate was too high, consequently this was reduced. This was accomplished by the use of an apparatus described by Gibbs[3] for measuring blood flow. By a slight alteration this instrument can be made to pump at a definite rate controlled by a time clock. (see Table II). No great differences were achieved. This suggested that the method was so crude that small differences would not appear. The effect of temperature on the curve was studied, since it became obvious that this was upsetting some of the results. The difference between room temperature (an approximately body temperature) is to increase the osmotic rise slightly. Thereafter work was carried on at this temperature controlled in a water bath.

So far the experiments had not brought to light any marked change. Instead therefore of merely circulating the fluid the apparatus was arranged to pump fluid past the mem-

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3. Gibbs, O. S., A New Method of Measuring Blood Flow., Transaction of the N. S. Institute of Science. 1928.

brane at a given speed. This resulted in a greater rise, but again no proportion was proven.

Experiments were then conducted on the permeability of the membranes. These experiments showed that permeability changes caused marked alteration of the osmotic rise. They further emphasized that the errors which were constantly appearing were in all probability associated with changes in the permeability of the membranes as yet uncontrolled. Before however taking up this problem in detail other salts were investigated, and it was found that a velocity effect could be demonstrated on 1% disodium hydrogen phosphate as the accompanying Table III shows.

Tables.

Velocity cc. per minute	Time taken minutes	Total rise cms.
Table I.		
0	110	9
400	75	15
570	70	14
800	75	16
1466	75	24
1600	60	17
Table II.		
5	110	20
8	110	19
12	110	19
36	95	22
Table III.		
1.5	90	35
6	90	49
18	58	52
36	67	67

Thus the fact becomes established that the velocity of the surrounding fluid may alter the temporary osmotic pressure developed by salt against water. Direct measurements on the actual diffusion rate of the salt have not been carried out, but it would appear that this also is altered. These results naturally suggest the importance of the blood flow on the absorption of substances in the tissues spaces, as well as their diffusion outwards.

The results obtained are not sufficiently accurate to warrant mathematical analysis. It is hoped however to repeat them, using more accurate methods which will involve most careful standardization of the membranes. Some of the results suggested—that a membrane alters its permeability on use, the cause at present being unknown, through accidental contamination is one possible sorce of error.

Summary.

1. It has been shown that the osmotic pressure rise developed by salt diffusing against distilled water is influenced by moving or changing the diffusate.

2. A rough relationship has been shown between the pressure rise and the velocity when 1% Na_2PO is diffused against distilled water.

This work was aided by a grant from the National Research Council.

An Attempt to Measure the Range of the Alpha Particle of Thorium.*—By J. L. Nickerson, M.A., Dalhousie University, Halifax, N. S.

(Presented 13 February 1929).

ABSTRACT.

The range of the alpha particle from thorium has been found from Wilson Chamber photographs to be 3.75 ± .1 cm. at 15°c.

The problem of measuring the range of the alpha particle of thorium has always presented difficulties on account of its small activity.

The results of earlier workers are:

In 1906	Bragg[1]	3.4 cm approximately
" 1911	Geiger and Nuttall[2]	2.72 cm
" 1917	J. Joly[3]	2.90 cm (considered high[4])

These values are all at 15° C. and 76 cm. of mercury.

The present work, performed under the supervision of Dr. H. L. Bronson, was suggested by Dr. G. H. Henderson as a continuation of the work of Mr. G. C. Laurence who determined the ranges of Uranium I and Uranium II[5]. Since these elements are active Mr. Laurence used a Wilson expansion chamber containing active sources of considerable area and of thickness equivalent to an absorbing powder of one millimeter of air.

Thorium is even more inactive than uranium so we expected to have greater difficulty in getting a sufficient number of tracks. The active sources were obtained by arcing between water-cooled metalic thorium electrodes by means of a 10,000 volt, 500 watt transformer. The pressure of the air was of the order of 10 cm. of mercury. The total arcing time was 6 hours in periods of 5 to 10 minutes with intervals for cooling The deposit of the evaporated material was accumulated on mica strips wound around the inside of the Pyrex glass tube forming the chamber in which the arcing took place. The thickness of deposit used was equivalent to one millimeter of air. This was estimated by weighing to .0001 gm and extrapolating from the table of Marsden and Richardson[6]. A total area of 9 sq. cm. of active source was inserted in the chamber.

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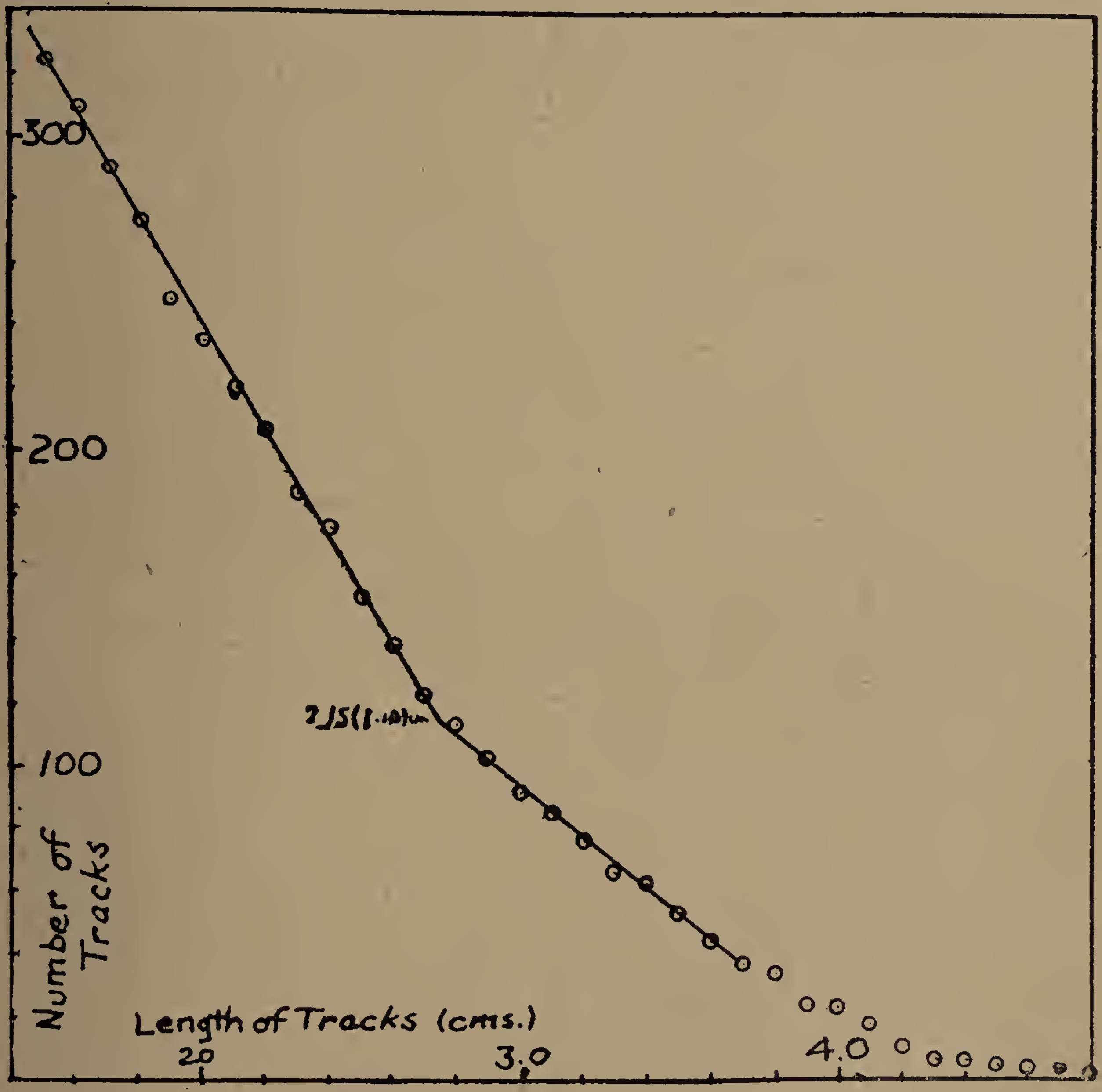
*With the assistance of a National Research Council Bursary.

(1) Bragg. Phil Mag 11, pg 754, 1906.
(2) Geiger and Nuttall. Phil Mag 22, pg 613, 1911.
(3) Jolly. Proc Roy Inst Great Britain 22, pg 115, 1917.
(4) Bulletin of the Research Council (Washington) No 51, pg 68, 1925.
(5) Laurence. Trans N. S. Inst Sci., XVII, part 1, pgs 103-106.
" also Phil Mag Vol V, pgs 1027-1028, May 1928.

As a result of much work more than 800 photographs were taken from which 323 accurately measurable tracks were obtained. (All tracks shorter than 1.50 cm. were disregarded). For each track more than 100 expanisons were required and as the whole thorium family was present the number of expansions per thorium track was very large. These tracks were corrected, as in the work of Mr. Laurence, for vapor pressure (to bring to dry air), finite thickness of source, obliquity to the photographic plate and temperature as determined by an external thermometer.



Results. (All results are for 15° C. and 76 cm. Hg).

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(6) Marsden and Richardson. Phil Mag 25, 1913.

The number of tracks of length greater than "x" were plotted against "x" (taking a point every millimeter) and the results obtained are shown in the figure.

A distinct bend in the curve at 2.75 cm. with a probable error of .10 cm. in the determination of this point. This would be due to the thorium alphas.

There are also dips in the curve at 3.70 cm., 3.90cm. and 4.30cm. The dip at 4.30cm. could be accounted for by thorium X, of known range 4.35 cm., which is certainly present as an impurity in the thorium used. We would also expect to have some tracks from radiothorium the isotope of thorium. These would be at 4.02 cm. and correspond to the 3.90 cm. dip within 3%, i. e., within the probable error at this point since it depends on a small number of tracks. The 3.70 cm. dip, if real, has a possible explanation in the foreshortening of the tracks by striking the top or the bottom of the chamber.

Discussion.

Since the straggling of the longer alphas of the thorium family causes a masking of the humps in the curve it is very improbable that piling up more tracks from active sources of the same type would improve matters sufficiently to give a more accurate value of the thorium range. To overcome this difficulty one should separate thorium and its radiothorium from their decay products by chemical means and, working rapidly, prepare sources, insert them in the chamber and take photographs up to a time not exceeding 12 hours after the separation. This would be an exceedingly slow and laborious process. For this reason the more easily prepared arced sources from thorium containing its decay products were used in the present work with the hope that an accurate value of the range would be obtained.

In conclusion I wish to express my appreciation of the advice and assistance of Dr. Bronson and other members of the Physics department at Dalhousie, to Mr. Laurence for initiating me into the technique and for other assistance and to Mr. H. C. Rentschler of the Westinghouse Lamp Co., for furnishing the thorium wire.

SOME MEASUREMENTS OF THE HEAT CAPACITY OF FISH MUSCLE.—

By H. RITCHIE CHIPMAN, PH.D., F.C.I.C. and GEORGE O. LANGSTROTH, B.A.

(Presented 13 February 1929)

ABSTRACT.

The heat capacities of the muscle of various fishes were determined in an adiabatic calorimeter. From these results the specific heat, latent heat, and freezing point were obtained. The fish investigated were brook trout, burbot, cod, haddock, herring, mackerel and skate.

The heat capacities were found to be the same for all fishes above the freezing point with the exception of mackerel. Below the freezing point the heat capacities vary with the species. As the heat capacity curves are almost parallel the specific heats are almost the same.

The water and fat content of the fishes were also determined and they are believed to be an important factor in the latent heats.

In refrigeration problems it is important to have data on heat transfer. Accordingly values were obtained for the heat capacity of the muscle of various fish. From these values it is possible to find the specific heat, latent heat, and the freezing point. The fishes examined were brook trout, burbot, cod, haddock, herring, mackerel and skate.

APPARATUS AND EXPERIMENTAL METHOD.

The method consisted in keeping a weighed amount of the fish in an initial bath at a constant low temperature and then transferring it to an adiabatic calorimeter where the heat change could be measured.

The apparatus used was an adiabatic calorimeter of the Richard's type.[1] The calorimeter proper was a copper vessel holding about 800 grams of water stirred by an "up and down" stirrer. The outer container was an earthenware vessel of about six gallons capacity stirred by four two-bladed propellers.

The temperature change of the inner bath was read by a Beckmann thermometer placed in the outer bath. The temperature adjustment between the baths was obtained by means of a thermocouple system of such a sensitivity that a difference of 0.0008° C. between the two baths produced a deflection of one millimeter on the galvanometer scale. The absolute temperature of the outer bath was read by a tenth degree thermometer inserted directly into it.

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[1] Maass and Waldbauer, Jour. Am. Chem. Soc. 47. 1, (1925).

The sample of fish was contained in a brass cylinder with a screw top. Its weight was about 13 grams and on the average about 11 grams of fish were used. The heat capacity of the empty container was determined over the same range of temperature as was used with the fish. It was found that the fish super-cooled very easily and to avoid this the fish were kept in the cold storage rooms at a temperature of about -18° C. By allowing the sample to warm up to the temperature of the initial bath instead of cooling down to it supercooling was avoided.

The bath in which the fish was brought to the required initial temperature consisted of a wide mouth thermos bottle carefully insulated with wool and placed close to the calorimeter to facilitate transfer. A copper tube into which it fitted tightly kept the container from actual contact with the cooling solution. This solution consisted of water for temperatures above 0° C.; salt and ice for temperatures beween 0° C. and -12° C.; and of ether and solid carbon dioxide for temperatures below -12° C.

The solution was stirred by a stream of dried air and the temperatures read by a toluol thermometer. The bath could be controlled to 0.1° C.

The sample was weighed in the container and allowed to remain in the initial bath for at least one hour, and, in cases where the initial temperature was near freezing point of the fish, for two hours. This time was found to be ample by preliminary experiments.

The calorimeter was then assembled, the water in the calorimeter being at such a temperature that it would be close to 20°C. at the end of the experiment, thus avoiding a large temperature correction, as 20° C. was taken as reference point. The baths were then balanced, being considered constant when the change in the Beckmann thermometer reading did not vary more than 0.002° over a period of ten minutes. The container was placed in the calorimeter and the heat changes followed by keeping the thermal balance between the two baths. The large initial temperature change could be followed to within 0.5°. After the initial change the two baths were kept to within 0.02°. When the temperature of the baths remained constant to 0.002° for ten minutes the run was considered as completed.

Since in the calculations the determined heat capacity of the container was subtracted from that of the container and fish, any heat loss in transfer was largely corrected. A rough value of the specific heat was calculated and the heat capacity was corrected to the required end temperature which was chosen as 20° C. The values were plotted against temperature and a smooth curve drawn through them. From this curve it was possible to obtain the freezing points, latent heats, and specific heats.

RESULTS.

The following results were obtained. In all the Tables the temperature is given in degrees Centigrade and the Heat Capacity in calories per gram.

The following values were obtained from three samples of brook trout received during the summer:

TABLE I.

HEAT CAPACITY OF BROOK TROUT.

Temperature	Heat Capacity	Temperature	Heat Capacity
60.8	36.1	– 3.1	– 65.5
50.3	26.8	– 6.3	– 72.4
40.5	18.0	– 6.4	– 72.8
0.0	– 22.0	– 9.8	– 78.8
0.0	– 20.7	– 11.7	– 80.2
– 0.7	– 26.2	– 13.0	– 81.4
– 1.4	– 43.3		

The following values were obtained from samples of burbot. Two fish were used and different results obtained. These fish were some of a lot which were sent to this Station from Ontario during the summer. The burbot is a fresh water fish.

TABLE II.

HEAT CAPACITY OF BURBOT.

First fish		Second fish	
Temperature	Heat Capacity	Temperature	Heat Capacity
51.5	28.2	- 1.3	- 43.8
0.0	- 18.1	- 5.5	- 77.2
- 1.1	- 41.1	- 10.8	- 83.7
- 1.1	- 43.0	- 12.4	- 84.8
- 1.7	- 53.7	- 12.8	- 85.9
- 4.9	- 75.0		
- 7.5	- 79.7		
- 10.0	- 82.1		
- 13.0	- 83.5		
- 13.5	- 84.3		
- 23.8	- 89.6		
- 38.5	- 98.1		

The following values were obtained from cod. Those marked * were from fish caught later in the summer, and it will be seen that they give a slightly different value.

TABLE III.

HEAT CAPACITY OF COD.

Temperature.	Heat Capacity.	Temperature.	Heat Capacity.
70.0	42.8	- 20.0	- 86.5
70.0	42.2	- 30.0	- 93.3
30.0	10.0	- 40.0	- 98.9
10.0	- 9.1	- 50.0	-103.0
10.0	- 9.7	- 60.0	-107.8
0.0	- 17.4	- 70.0	-110.7
0.0	- 18.3	- 70.0	-111.7
- 1.0	- 36.2	0.0	- 23.8*
- 2.0	- 60.0	0.0	- 24.4*
- 5.0	- 72.3	- 5.0	- 68.7*
- 5.0	- 70.5	- 5.0	- 69.7*
- 10.0	- 81.0	- 10.0	- 78.5*
- 10.0	- 80.5	- 10.0	- 78.3*
- 20.0	- 86.5		

The following values were obtained from haddock. Three fish caught during early summer were used. Those values marked * were from fish caught later in the summer and like cod a slightly different value was found.

TABLE IV.

HEAT CAPACITY OF HADDOCK.

Temperature.	Heat Capacity.	Temperature.	Heat Capacity.
60.7	36.4	– 4.5	– 71.0
50.2	26.8	– 4.6	– 69.9
40.2	17.9	– 4.6	– 69.5
0.0	– 16.9	– 6.4	– 75.9
0.0	– 16.9	– 6.8	– 77.1
0.0	– 18.1	– 10.5	– 80.2
– 0.5	– 20.2	– 10.5	– 80.0
– 1.0	– 41.3	– 12.8	– 82.6
– 1.3	– 41.3	– 14.2	– 82.5
– 2.0	– 50.9	– 43.2	– 94.0*
– 2.2	– 52.4	– 41.7	– 94.0*
– 4.2	– 69.5	– 11.2	– 78.5*
		– 11.8	– 78.5*

The following values were obtained from two samples of "fat" herring received during the middle of July.

TABLE V.

HEAT CAPACITY OF HERRING.

First fish		Second fish	
Temperature.	Heat Capacity.	Temperature.	Heat Capacity.
61.1	35.8	– 1.6	– 32.2
0.0	– 17.1	– 3.0	– 51.4
– 1.4	– 36.2	– 7.2	– 67.1
– 3.2	– 58.6	– 10.1	– 72.4
– 6.6	– 71.1	– 12.9	– 73.5
– 10.2	– 74.2		
– 12.7	– 77.8		
– 24.9	– 82.5		
– 42.5	– 87.9		
– 42.3	– 87.4		

The following values were obtained from two samples of "fat" mackerel received in the late fall.

TABLE VI.

HEAT CAPACITY OF MACKEREL.

Temperature.	Heat Capacity.
36.0	12.6
0.0	– 14.7
0.0	– 15.6
– 1.0	– 29.9
– 2.0	– 42.5
– 5.0	– 54.5
– 10.0	– 64.1
– 10.0	– 64.5

The following were obtained from one sample of Skate.

TABLE VII.

HEAT CAPACITY OF SKATE.

Temperature.	Heat Capacity.	Temperature.	Heat Capacity.
61.0	36.4	– 8.0	– 70.9
0.0	– 16.9	– 11.0	– 76.4
0.0	– 17.5	– 11.6	– 78.0
– 2.0	– 25.3	– 12.7	– 79.7
– 2.8	– 36.2	– 20.0	– 84.2
– 4.8	– 59.7	– 23.3	– 83.8
– 6.0	– 64.5	– 41.7	– 96.4

The results given in Tables I-VII are shown in Fig. 1.

LATENT HEAT, SPECIFIC HEAT, AND FREEZING POINTS.

The latent heat, specific heat, and the freezing point may be obtained from the curves which are shown in Fig. 1. The freezing point is obtained by extrapolating the curve and is good only to about 0.2° C. The Latent Heat is the difference between the heat capacity at the freezing point and the point where the curve begins to straighten out. The specific heat is obtained in the usual manner.

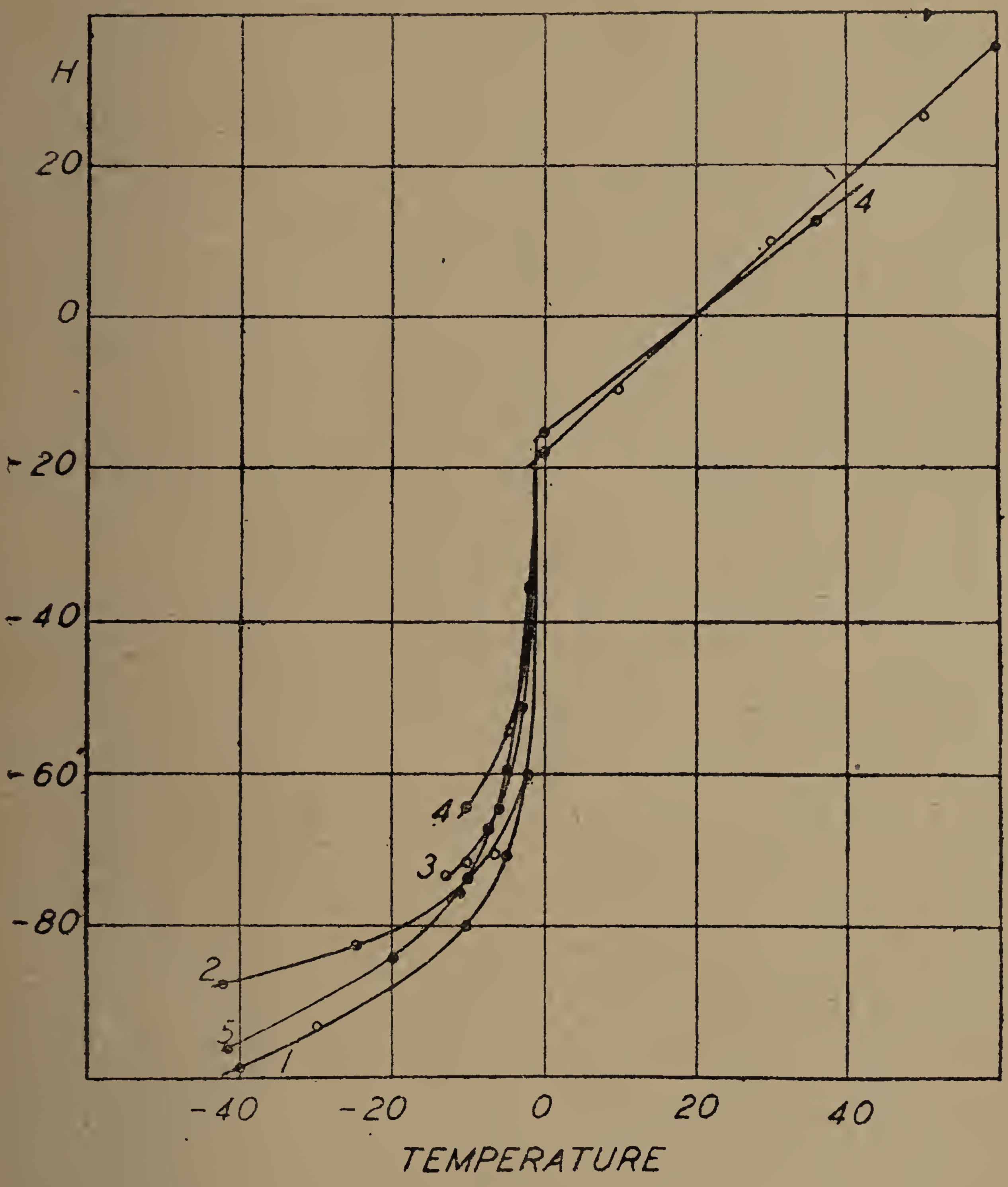

Figure 1.

HEAT CAPACITIES OF FISH MUSCLE.

TABLE VIII.

LATENT HEATS, SPECIFIC HEATS, AND FREEZING POINTS.

	Latent heat.	Specific heat		Freezing point.
Haddock and Cod	63 cals/gm	0.0° to 60°	0.89	– 0.8° C
		–10° to –20°	0.70	
		–20° to –30°	0.63	
		–30° to –40°	0.56	
Skate	60 cals/gm	0° to 60°	0.89	– 1.8°
		–20° to –30°	0.63	
		–30° to –40°	0.56	
Herring	57 cals/gm	0° to 60°	0.89	– 1.0°
	54 "	–10° to –20°	0.63	
		–20° to –30°	0.40	
		–30° to –40°	0.26	
Burbot	64 cals/gm	0° to 60°	0.89	– 0.8°
		–10° to –20°	0.68	
		–20° to –30°	0.63	
		–30° to –40°	0.56	
Brook Trout	62 cals/gm	0° to 60°	0.95	– 0.8°
Mackerel	48 cals/gm	0° to 36°	0.78	– 0.8°

WATER AND FAT ANALYSIS.

Since it was thought that the water content of the fish muscle affected largely the value of the heat capacity, it was determined in two ways; one by means of a vacuum desiccator and the other by passing dry air over the sample heated to about 105° C. The first was probably the better method since in the latter there may be some volatile material carried off in the air stream.

The vacuum desiccator was of the usual type, sulphuric acid being used as a drier. About eight grams of fish, finely sliced, were used in each determination. The fish was allowed to dry for a day and a half and the weighings were made every hour and a half. When the weighings were constant to 0.004 gm. the determination was finished.

When dried by the air stream, the fish was placed in a small flask which was immersed in a salt solution at 105° C. Air, dried by passage over concentrated sulphuric acid, was passed over it and then through some more sulphuric acid to detect the presence of organic material which had been volatilized. Organic material would discolour the acid. It was found there was a very slight discoloration denoting only a very small amount of organic material being given off.

Samples from the same fish as used in the heat capacity determinations were not always available; but the analysis was made from fish caught at the same time and which had passed through the same handling.

The following results were obtained.

TABLE IX.

WATER CONTENT OF FISH MUSCLE.

Muscle	Percentage water	Average
Burbot	82.8	
	83.5	83
Cod	79.9	
	80.4	80
Haddock	80.3	
	79.1	80
Herring	64.5	
	64.0	
	65.7	65
Mackerel	58.0	
	58.2	58
Skate	78.6	
	80.6	80

The water analyses were carried out on samples from the same fish as was used in the heat capacity determinations except in the case of cod and haddock.

The fat content of the fish muscle was determined by extraction with naptha. The same fish as were used for the water analyses were used. The following results were obtained.

TABLE X.

FAT CONTENT OF MUSCLE.

Muscle.	Percentage fat.
Burbot	0.3
Cod	0.3
Haddock	0.3
Herring	13.3
Mackerel	25.2
Skate	1.8

With the exception of the analyses of the mackerel all of the fat analyses were carried out by Miss Anna M. Wilson, Technical Assistant at the Experimental Station. At the time of analysis there were no longer any samples of trout available.

DISCUSSION.

The heat capacity curves are shown in Figure 1. Above 0°C. with one exception, the heat capacity curves correspond within the limit of experimental error. This exception is in the case of mackerel, which the analyses show to contain considerably more fat and less water than any of the other fish examined.

Below 0° C. there is a very marked difference in the heat capacity curves. Both the magnitude and the direction of these differences lead to the conclusion that the water content is the important factor in the latent heat.

Slight differences in the latent heat for two fish of the same species were noted, but the specific heat was always the same for the same kind of fish, as shown by the parallelism of the herring and of the burbot curves.

The results are good to about 1% for the samples examined. The latent heats do not apply that closely for all fish of the same species because of such variations as are to be noted in the case of the two investigated samples of herring and burbot. The specific heat does not vary by more than the experimental error for different fish of the same species. It is good to about 1.5% between 0° and 60° and to about 1% for the various points below –10° C.

ICHTHYOPHONUS HOFERI, PLEHN and MULSOW, A FLOUNDER PARASITE NEW TO NORTH AMERICAN WATERS:—Studies from the Department of Zoology, Dalhousie University, and the Atlantic Biological Station, St. Andrews, N. B., By MARJORIE F. ELLIS, B.A., Dalhousie University, Halifax, N. S.

(Presented 13 March 1929)

ABSTRACT.

The form *Ichthyophonus hoferi*, Plehn and Mulsow, is reported as occurring in a marine form, the winter flounder, *Pseudopleuronectes americanus*, (Walbaum). This is the first report of this organism in other than European waters and the first instance of its occurrence in salt water.

Nodular masses ranging in size from 2 mm. to 5 cm. in diameter were found in the coelomic cavity and viscera.

Microscopic examination revealed an encysted organism which, when placed on the slide, sent out protoplasmic processes resembling the plasmodia of the Myxomycetes.

In stained preparations the striking reactions set up in the host tissue are apparent.

Certain infection experiments on other flounders are described.

The obscure micro-organism, *Ichthyophonus hoferi*, Plehn and Mulsow, was first described by Hofer as the cause of "*Taumelkrankheit*", "dizziness disease," in trout and salmon. Since then several cases have been reported in fishes in fresh waters of Europe.

The disease has been found to attack practically all the body organs of the host, and in some cases the brain has been the major seat of infection.

As far as can be ascertained the organism has never been reported in other than European waters and there only in fresh water.

The purpose of the present paper is to report the occurrence of this disease in an American food fish, the winter flounder, *Pseudopleuronectes americanus* (Walbaum). The infected hosts were taken in commercial fishing operations in Passamquoddy Bay and were discovered by the writer in the course of pathological examinations of the landed catch at St. Andrews, New Brunswick. The fish had been dead several hours and were partially eviscerated before they came under observation.

Large creamy-white masses approximately 5 cm. in diameter adhered to the body wall. The parts of the viscera remaining in the animal were invaded with numerous smaller nodular masses of the same appearance and about 2 mm. in diameter.

Fresh smears of these nodular masses were microscopically studied. They were found to be composed of colonies of organisms of a most peculiar appearance. When first placed on the slide these organisms were inclosed in a transparent colorless cyst, about 50μ. in diameter. Almost immediately long amoeboid-like pseudopodia, closely resembling the plasmodium of a myxomycete, appeared leaving the empty cyst-case behind. These protoplasmic protrusions, some of which reached a length of 100μ appeared to emerge through a single opening in the cyst wall from 4 to 5μ. in diameter. These processes were filled with granular protoplasm, the granules of which were 2μ in diameter. Although the material was kept on the slide for some hours no further change took place. Plehn and Mulsow in 1911 described the protoplasm as migrating to the ends of the pseudopodia, and there forming spherical masses which divided into smaller cysts with a firm shell, and resembling the common cyst in color. They considered this to be a resting stage and called them the secondary cyst fruiting bodies. These were not observed in the present case. A block of the tissue was kept in running sea water and examined two days later. Only empty cyst cases remained.

Material for stained preparations was fixed in Bouin's picroformal solution and stained with Heidenhain's Iron Alum and Orange G.

In stained sections the protoplasm was found to contain numerous deeply staining granules 1.5μ in diameter and surrounded by a clear membrane about 1μ in diameter. Plehn and Mulsow consider these structures to be nuclei, and the dark granule in the center the nucleolus. Other granules embedded directly in the protoplasm have been described by Plehn and Mulsow in 1911 and Laveran and Pettit in 1910.

In the present material they were observed in a single case in which the other granules were absent. It is impossible at present to state the significance of this fact.

The host tissue shows very striking reactions to the parasite. In the case of sections made from diseased kidney the cells of the kidney tubules have become greatly modified and together with the hypertrophied adjoining connective tissue make up a wall surrounding the encysted parasite. Examination of the tissue had disclosed only one cyst not surrounded by a wall. This would strongly indicate that the avenue of infection in the kidney is through the uriniferous tubules. However, the freed plasmodia of the parasites occur as naked structures directly in the host tissues, showing clearly that, whatever the avenue of infection may be, the released organisms, far from being restricted to the lumina of the uriniferous tubules occur, in the majority of cases not in the lumina but scattered freely in a connective tissue matrix.

In sections from the large mass which adhered to the body wall the host tissue has formed connective tissue rings around one or more of the encysted parasites and, as before, the freed plasmodia appear directly embedded in the host tissue.

It is interesting to compare these reactions of the host tissue with the reactions set up by the nematode worm, *Trichinella spiralis* (Owen). In this case, after the connective tissue walls have been formed a calcareous deposit is laid down by the host. This process results in the formation of a hard calcareous nodule enclosing the parasite.

Some attempts were made to infect other flounders. Two young flounders were infected, one by scraping the walls of the branchial cavity and rubbing in some of the diseased tissue; the other by inserting some diseased tissue into the coelomic cavity through an incision in the body wall. The flounder infected in the branchial cavity gave negative results. The animal infected in the coelom died six days later. Careful examination was made for traces of infection. On the walls surrounding the incision some empty cyst cases and round protoplasmic spherules, much smaller than the original cyst, were observed. Some of these had a large central granule and resembled the fruiting bodies described by Plehn. This material was used to make further infection on a fresh flounder with negative results. Owing to the fact that the material was kept on the slide for some hours the organisms may have died before the infection was made.

Hofer in 1893 first described this form without naming it or attempting to give it any place in the system of classification.

In 1910 the disease was reported by Laveran and Pettit. It appeared in the establishment of a fish culturist in France and was causing a high mortality among the fishes. These writers described the organism as reproducing by means of small secondary cysts which were derived from a division of the primary protoplasmic body and were set free by a splitting of the cyst wall. These secondary cysts were observed in the excretions of diseased trout. They consider this to be the ordinary means of propagation of the parasite. These writers did not name the organism. They stated that they believed it had affinities with the protozoa, especially the Haplosporidia, but that certain details of structure seemed to be of a plant nature.

In December 1910 two dead rainbow trout came under the observation of Plehn and Mulsow and further investigations were carried on. These writers came to the conclusion that the organism did not belong to the sporozoa nor to the animal kingdom at all; but that it was one of the lower fungi. They named it *Ichthyophonus hoferi*, Plehn and Mulsow, and classed it in the Phycomycetes in the neighborhood of the Chytridinae.

They found it possible to grow the organism on a gelatine medium but were unable to trace fully its life history. They describe the formation of fruiting bodies which are in all probability identical with the secondary cysts described by Laveran and Pettit.

In response to correspondence Henry O'Malley, Commissioner of the United States Fisheries, (which organization carries on extensive researches in fish pathology throughout

North America) states that his investigators have found no instances of the occurrence of this disease.

The conclusion reached by the writer is that the form discussed in the present paper is identical with the form described by Hofer, Plehn and Mulsow, and Laveran and Pettit as the etiological agent in "dizziness disease." The occurrence of the form reported here is in a marine fish. The diseased animals exhibited an extensive and profound character of infection and bodily change. Microscopic study revealed an extensive permeation of the host tissues by the parasites outside the cysts themselves. Certain infection experiments were carried out on fresh fish which were not attempted by previous investigators on the organism. The result of these was the formation of protoplasmic spherules which resembled the fruiting bodies described by Plehn and Mulsow. The form is particularly interesting because of the obscure affinities of the parasite itself and the profound disturbance produced in the host.

In the preparation of this paper I am indebted to the Biological Board of Canada for the facilities provided for my work at St. Andrews, and to Professor James Nelson Gowanloch for his assistance and criticism.

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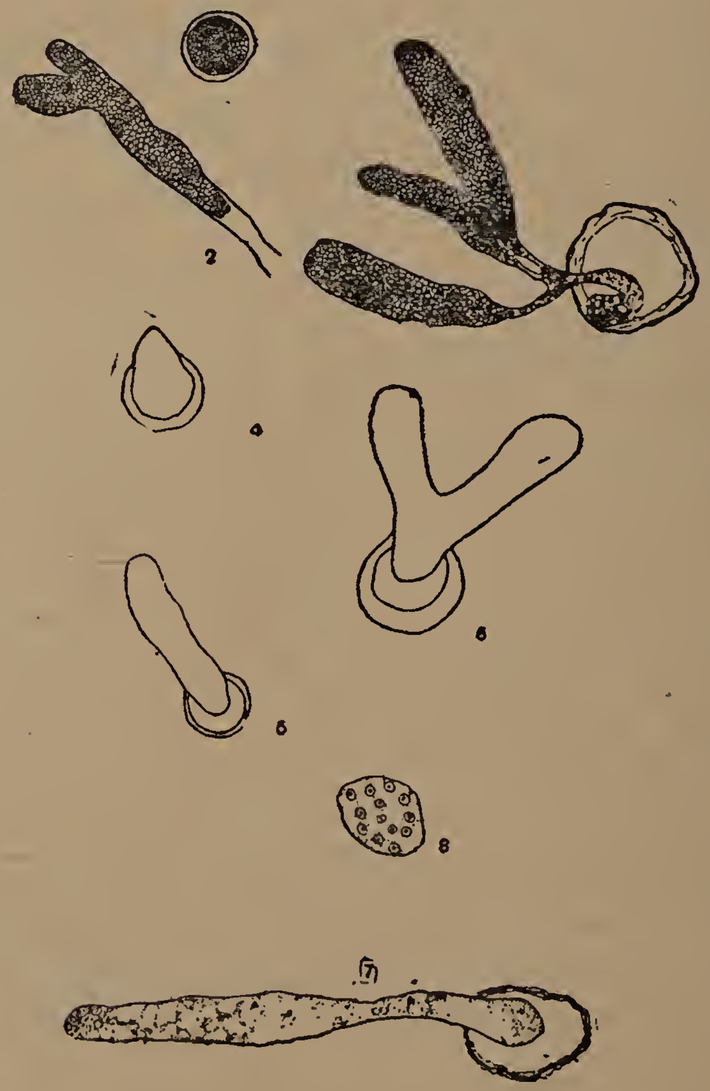
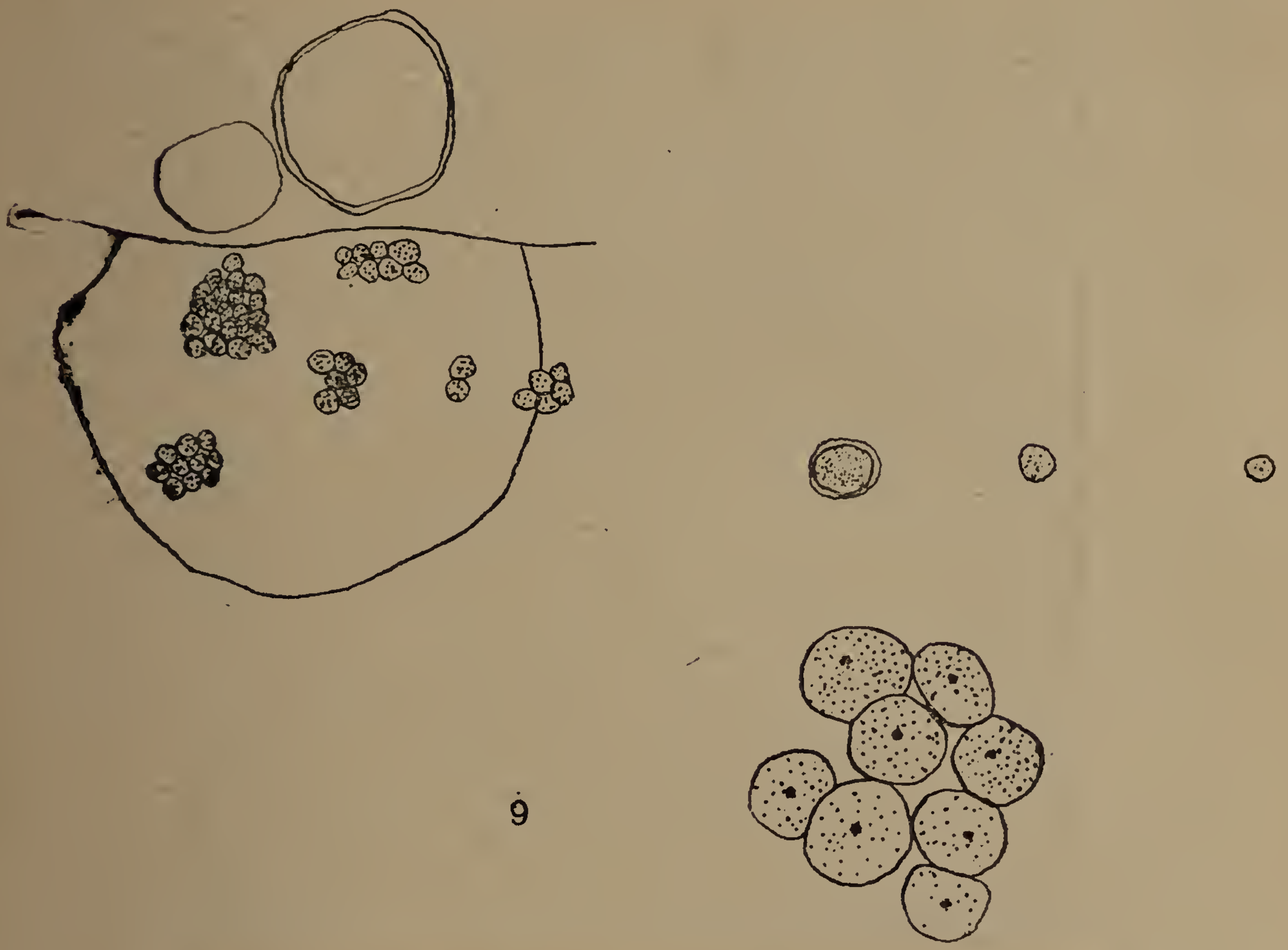
Fig. 1 Encysted animal. Fresh preparation. x 475.
Fig. 2 Pseudopodium with the protoplasm beginning to migrate to the end. Fresh preparation. x 475.
Fig. 3 Complete animal with extended psuedopodia. Fresh preparation. x 475.
Figs. 4, 5, & 6. Outlines of organisms showing the pseudopodia in different stages of growth.
Fig. 7 Organism drawn from stained preparation showing granules embedded directly in the protoplasm. x 475.
Fig. 8 Section through a pseudopodium showing the granules surrounded by a clear membrane. x 475.
Fig. 9. Cyst case enclosing protoplasmic spherules and escaped spherules showing central granules. Fresh preparation. x 475.
Figs. 10 & 11 Photomicrographs of individuals from smears stained with Heidenhain's Iron-Alum. x 100.
Fig. 12 Photomicrograph of section of nodule found in the kidney, showing modified uriniferous tubules. x 220.





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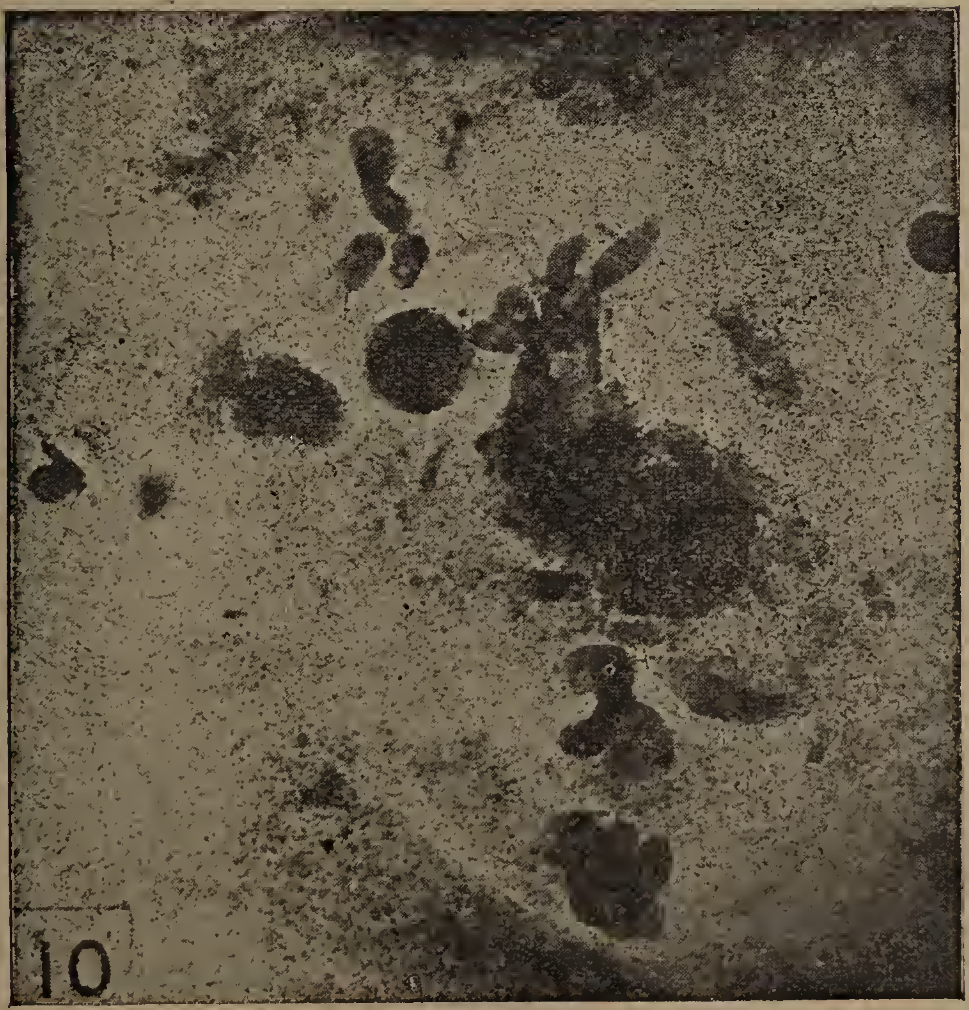

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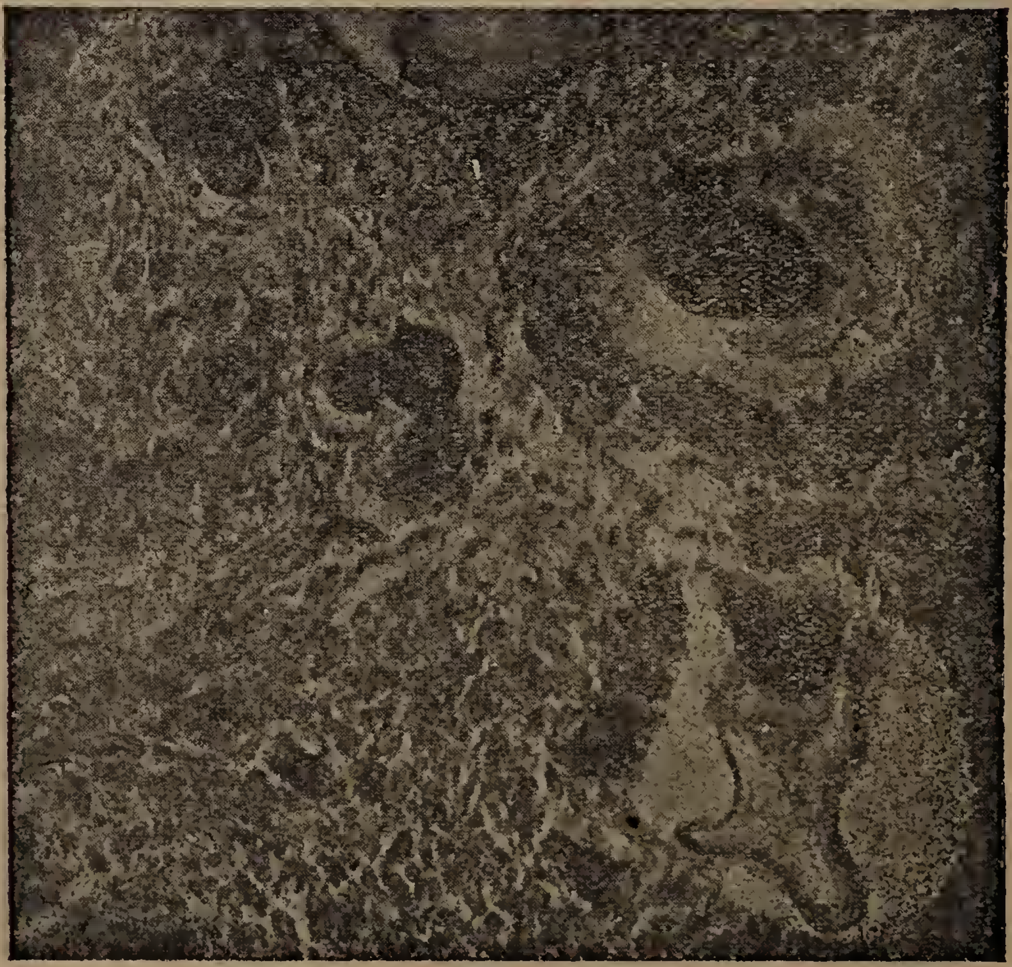


REDUCTION OF METANITROBENZALDEHYDE WITH SODIUM ARSENITE.—

By H. E. BIGELOW, PH.D. and JEAN H. PHILP, Chemical Laboratory, Mount Allison University, Sackville, New Brunswick.

(Presented 15 April 1929)

ABSTRACT.

In a study of sodium arsenite as a reducing agent in organic chemistry it was decided to examine its action on metanitrobenzaldehyde containing, as it does, two groups capable of reduction. This compound has been reduced by many investigators who have obtained varying products with various reducing agents; but in no case has azoxybenzyl alcohol been produced directly. Rarely, indeed, have both groups been attacked.

m-Nitrobenzaldehyde treated with sodium arsenite in excess at 105-6°C. for several hours gave m-azoxybenzyl alcohol and m-azoxybenzoic acid. This action is unique and affords a simple and direct method for preparing m-azoxybenzyl alcohol previously made indirectly and in small yield from m-nitrobenzaldehyde. This alcohol will be further used in connection with a study of the isomerism of azoxy compounds.

An examination of sodium arsenite as a reducing agent in the preparation of azoxybenzene from nitrobenzene[1] suggested a study of its action on metanitrobenzaldehyde, a compound in which two groups, a nitro and an aldehyde, both capable of reduction, would be at the same time subject to its action.

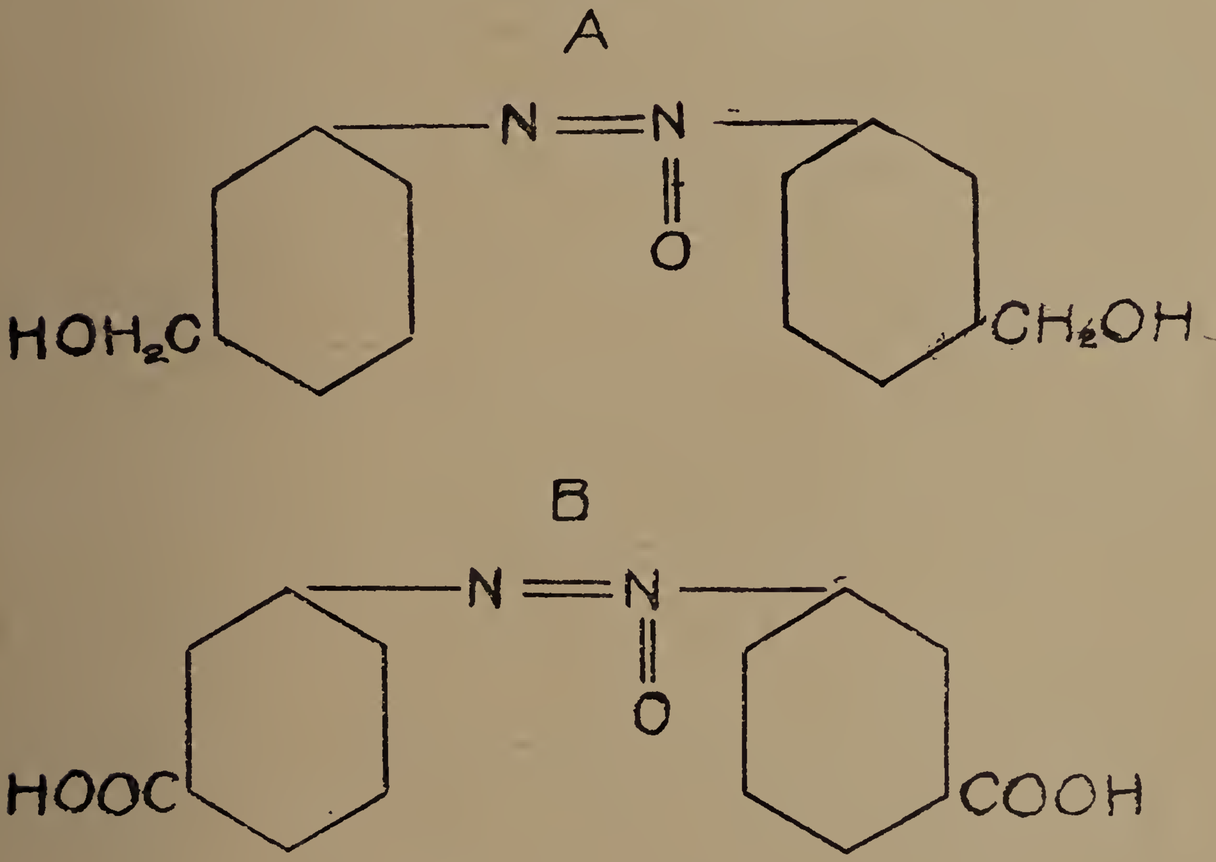
The reduction of this compound has been studied by numerous investigators who have obtained varying products, according to the reducing agent used. Treated with zinc dust[2] and water, alone or in the presence of various neutral solvents and reagents, it has been found to give a condensation product $(C_7H_5ON)x$ which on oxidation gives m-nitrosobenzaldehyde. With zinc dust[3] alcohol and acetic acid m-hydroxylaminobenzaldehyde and N–[3-formyl 1–phenyl]–3-nitro-isobenzaldoxime were the products. Electrolytic reduction[4] in strong sulphuric acid gave the same benzaldoxime as above. Long continued it gave a brown compound which oxidized to m-nitrosobenzaldehyde[5] and m-azoxybenzyl alcohol. Stannous chloride[6] in hydrochloric acid gave m-aminobenzaldehyde. In alkaline solutions quite different products were to be expected. Ferrous sulphate[7] and sodium hydroxide gave m-azoxybenzaldehyde. The reduction of the bisulphite compound of m-nitrobenzaldehyde with ferrous sulphate[8] and calcium carbonate and heating of the reduction product with hydrochloric acid or sulphuric acid until sulphur dioxide was driven off gave m-amino-benzaldehyde. Potassium hydroxide[9] in alcohol or water gave m-nitrobenzyl alcohol and m-nitrobenzoic acid. Strong sodium hydroxide (40°Bé) gave m-nitrobenzoic acid and m-azobenzoic acid[10]. Electrolytic reduction[11] in aqueous alcoholic potassium hydroxide gave 3-m-oxymethyl-azobenzol-carboxylic acid-3 and small amounts of m-azobenzyl alcohol and m-azobenzoic acid. Aluminum ethylate[12] gave m-nitrobenzoic acid ester. Only one of the reducing agents, ferrous sulphate, gave directly an azoxy compound.

In view of the well known simultaneous oxidation and reduction of two molecules of benzaldehyde in the presence of strong alkalies, one might expect that a reducing agent active in strong alkaline solution, might be found which would give both azoxy alcohol and azoxy acid when acting on a nitro-aldehyde. None of the reducing agents so far used, however, has given both these products; and indeed none has given m-azoxybenzyl alcohol which was first made from m-nitrobenzyl alcohol by reduction with 10% aqueous sodium hydroxide,[13] m-nitrobenzyl alcohol in turn being made from m-nitrobenzaldehyde[9]. The action of sodium arsenite on m-nitrobenzaldehyde is unique in that it gives both m-azoxybenzyl alcohol and m-azoxybenzoic acid.

Experimental Part.

30.6 grams of m-nitrobenzaldehyde and a sufficient quantity of sodium arsenite to reduce both the nitro and aldehyde groups and to give twenty five percent excess were added with water, in a total volume of 250 c.c., to a three hole Pyrex flask with thermometer, mechanical stirrer and reflux condenser attached. The mixture was heated in an oil bath, at a temperature sufficient to keep the reaction mixture in the flask at 105°—6° C., for eight hours with vigorous stirring. 200c.c. of water was then added to the mixture and the heating interrupted. After thorough mixing and slight cooling a yellow flocculent precipitate appeared. The contents of the flask were poured out and enough water added to make the volume about one liter or sufficient to prevent sodium arsenate from crystallizing out. After cooling, the organic matter was filtered off, washed thoroughly with water, and dried on a porous plate. Crystallization from alcohol and water and finally from benzene gave a product, crystalline and golden yellow in color melting at 86° C., the melting point of m-azoxybenzyl alcohol, Fig. I. A. An analysis for nitrogen gave 11.04%. The calculated value is 10.86%. The compound is therefore m-azoxybenzyl alcohol. Yield 25%.

Fig I



The water solution from which the m-azoxybenzyl alcohol had been separated was red in color. Extraction with various solvents, ether, chloroform, carbon tetrachloride, petroleum ether, gave only slight extracts. The solution was acidified. The red color disappeared and a heavy brownish-white gelatinous precipitate was formed. It was filtered with difficulty and the dried precipitate was found to be very insoluble in all ordinary organic solvents. It dissolved easily in sodium and ammonium hydroxide in agreement with our expectation that it was m-azoxybenzoic acid, Fig. I.B. The precipitate was several times dissolved in ammonium hydroxide and reprecipitated with hydrochloric acid but the brown color persisted. The original investigators describe it as a yellow powder without a sharp melting point but decomposing above 250°C. After these reprecipitations it was washed with water to remove the inorganic salts present, but because of its gelatinous nature this was imperfectly done. It was then extracted in a Soxlet extractor with 90% alcohol for several days. The color remained and very little of the original matter dissolved but the inorganic salts were completely removed. The product was brownish-yellow and amorphous, and decomposed at an uncertain temperature above 300°C. Analysis:

Mol. weight (Camphor method)	Calc. for $C_{14}H_{10}O_5N_2$	Found
	286	285

Calc. for $C_{14}H_{10}O_5N_2$, $N = 9.72\%$ Found. $N = 9.79\%$. Despite the slightly brownish color the compound is evidently m-azoxybenzoic acid.

The products, therefore, obtained by reducing m-nitrobenzaldehyde with excess of sodium arsenite at 105°—106° C are m-azoxybenzyl alcohol and m-azoxy-benzoic acid, both the nitro and aldehyde groups being reduced.

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AN ADIABATIC CALORIMETER FOR LOW TEMPERATURE MEASUREMENTS.

—By D. LEB. COOPER, M.Sc., and D. MCINTOSH, D.Sc., Department of Chemistry, Dalhousie University, Halifax, N. S.

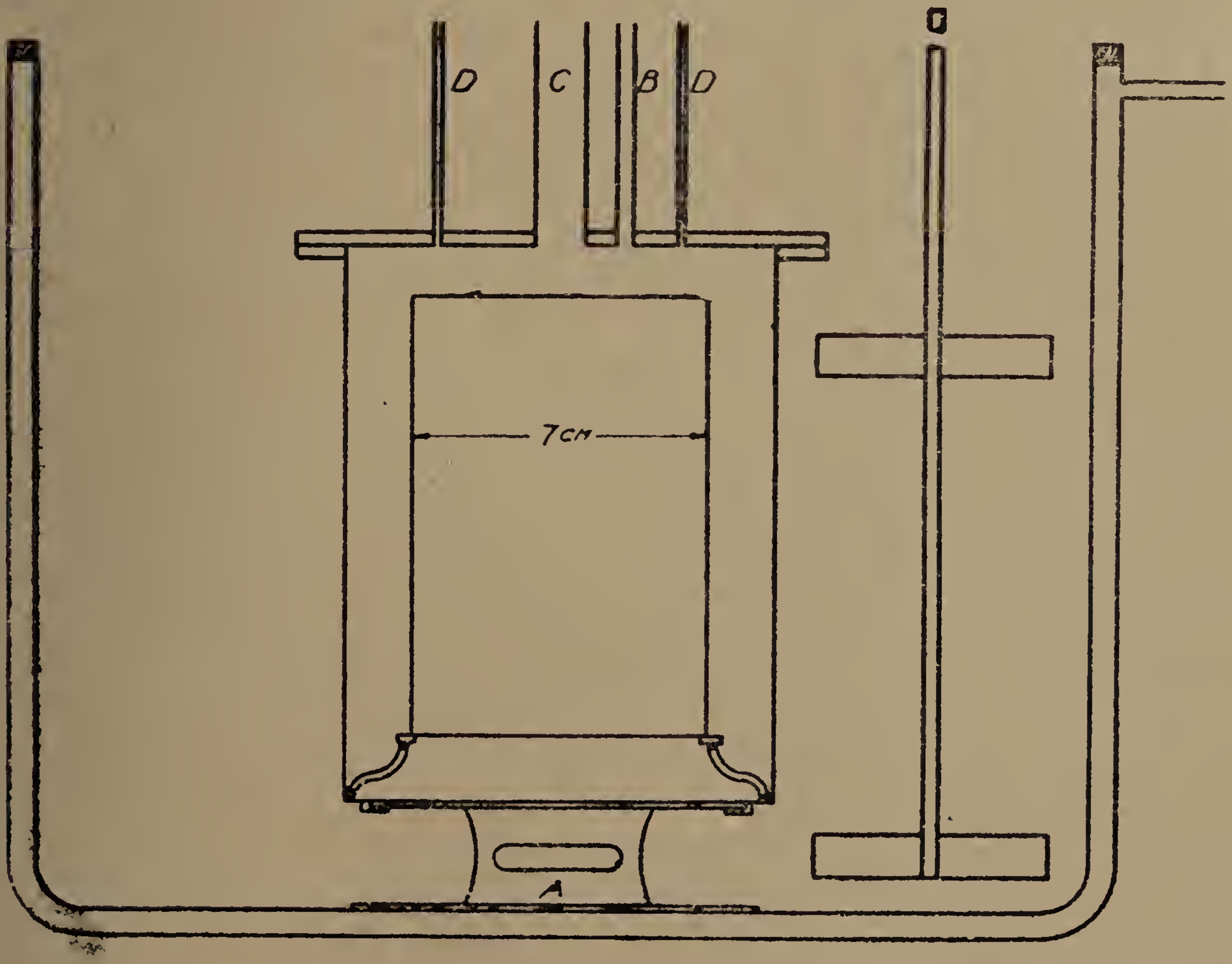
(Presented 15 April 1929)

ABSTRACT.

This calorimeter was designed to enable measurements to be made on the heats evolved in certain reactions with organic substances at a temperature at which substitution does not take place.

The calorimeter was of the Richards type, with an outer vacuum jacket of copper. The calorimeter liquid was a mixture of chloroform and carbon tetrachloride, and the inner and outer liquids were kept at the same temperature by the addition of small amounts of solid carbon dioxide to the outer container.

A number of years ago, one of us measured the heats of formation of certain hydrobromic acid-oxonium compounds in a small calorimeter of special design. Since that time, the accuracy of heat measurements has increased greatly, and we had hoped to repeat and extend the study of these compounds. For our purpose the experiments must be made at a low temperature to prevent evaporation and substitution. We have therefore designed a small Richards calorimeter which can be used without serious inconvenience at low temperatures.



The apparatus shown in the diagram, was constructed by Mr. G. Sandos to whom our thanks are due. It is essentially the same as the ordinary calorimeter with four stirrers, but the outer chamber was a copper Dewar flask, 15 cm. wide and 20 cm. deep, connected to a pump which maintained a good vacuum (0.001 mm).

The bomb of the size shown is firmly held in place in the outer tank by an automatic catch, A, soldered to the bottom of the tank. The top of the bomb is flanged, and fitted with a rubber gasket to insure absolute tightness. The cover of the bomb is fitted with four tubes which serve the following purposes:—

Tube B—For the entrance of one point of the thermal.
Tube C—For a reaction bomb tube or other apparatus.
Tubes D-D To admit silk threads, which are fastened to a glass circle. The circle is moved by an eccentric, and serves as a stirrer for the inside bath, (the calorimeter vessel proper).

The inside calorimeter is insulated from the bomb by means of three hollow glass legs. These are constructed so that the calorimeter becomes automatically centered when allowed to enter the bomb, permitting an air space of 1.5 cm. between the calorimeter vessel and bomb.

The vacuum tank is closed with a wooden cover which is fitted with apertures to allow the admission of all the required apparatus of the outer bath.

For a solution for the outer bath, a mixture of chloroform and carbon tetrachloride (49% by weight) served admirably. This solution is cooled to the desired temperature by dropping in solid carbon dioxide, and regulated to the temperature of the inner bath by adding carbon dioxide moistened with chloroform mixture. If the outer bath requires to be warmed, due to an increase in temperature of the contents of the calorimeter proper, a small 200 watt heater is used.

Temperatures above the freezing point of mercury may be read by means of a Beckmann thermometer placed in the outer bath; temperatures lower than this require a platinum thermometer.

Preliminary tests on the specific heat of ether proved quite satisfactory, and we believe that the calorimeter is well adapted for the purpose we have in view.

INTESTINAL REACTION TO DRUGS IN DIFFERENT FISHES.—By N. B. DREYER, Department of Pharmacology, McGill University, Montreal, (and at the Marine Biological Laboratory, Woods Hole, Mass., U.S.A.).

(Presented 14 November 1928)

ABSTRACT.

In elasmorbranchs the vagus seems to exert very little effect on the gut movements, since pilocarpine in small or big doses produces no change.

Urea is not essential in perfusing fluids for elasmobranch organs.

Bony fish gut receives a motor supply from the vagus and an inhibitory supply from the sympathetic.

The response of mammalian gut to different drugs has been repeatedly studied and the reactions of the two types of nerve endings—sympathetic and parasympathetic—can be easily brought out in isolated strips of intestines or of the gut *in situ*. Very little evidence has been brought forward as to the innervation of the alimentary canal of fish. It has been found that electrical stimulation of the sympathetic gives rise to a motor response in the dogfish, and that the vagus has little or no effect on the gut movements.

The results described below were obtained while working at The Marine Biological Laboratory at Woods Hole during the summer of 1928. It was originally intended to record the movements of the intestine *in situ*, but, as the spinal dogfish is quite a lively animal, this method was discarded, and perfused strips of intestine used instead.

The nutritive fluid was made up according to the formula of Mines[1] in which urea in concentration of 2% seems to be essential, but was modified by adding sodium bicarbonate, 0.5 gram per liter. The parts selected for study were the ascending limb of the stomach and the spiral intestine. The figures reproduced below were obtained by registering the movements of the longitudinal coat only.

It has been claimed that urea is essential in solutions for perfusing the isolated elasmobranch heart[2]. With this in view the urea content was cut down to 1%, sodium chloride being added to maintain the osmotic pressure of the fluid constant. On replacing all the urea by sodium chloride, the intestine was found to beat quite well (Fig. I), the contractions were as good as when urea was used. Fig. II shows the movements of the same piece of gut when urea in 2% concentration was restored to the perfusing medium. This change of rhythm was often noticeable in a strip of muscle where urea was kept constant. In all cases, whether urea was cut down to half its original concentration or left out completely, the response to adrenaline was unaltered. A fact not to be overlooked is the absence of sodium bicarbonate from Mines' solution. The addition of this substance no doubt makes it possible to leave out the urea. It is possible that a small amount of ammonia liberated from the urea acts as a buffer. The presence of ammonia in a solution of urea standing at room temperature is easily detected by its odour, and is well marked after twenty-four hours. In some cases urea was not replaced by sodium chloride, yet in spite of this strips of intestine went on contracting with hardly any change in tone or rhythm. The urea would seem to play a part in the intact animal as regards keeping the osmotic pressure of its tissue fluids constant, but does not seem to be essential for isolated organs.

For routine perfusion of intestinal or stomach strips from skates or dogfish, a solution of the following composition was used:— $NaCl$ 1.8%, KCl 0.05%, $CaCl_2$ 0.04%, $MgCl_2$ 0.05%, Urea 1.0%, $NaHCO_3$ 0.05%.

The stomach and the intestines are innervated from two sources—the vagus and sympathetic nerves. By analogy with mammalian tissues one would expect the vagus to be motor and the sympathetic to be inhibitory in action. Electrical stimulation, e.g. of the vagus, in the mammal does not give uniform results, and in view of the results obtained previously, electrical stimulation of nerves was not carried out. It was thought that drugs which affect the nerve-endings might prove suitable in determining the nature of response given by the vagus and the sympathetic.

Pilocarpine was selected for stimulating, and atropine for paralysing, the vagal endings while adrenaline was used for stimulating the sympathetic. Fig. III shows the results obtained with pilocarpine. The movements were unaffected by this drug, the gut continuing its normal rhythm. The capacity of the container was 75 c.c. so that the dilution of the drug was not excessive. The doses used are sufficient to cause mammalian intestine to contract strongly, but even when the amount of pilocarpine was raised to 10 mg. no effect could be produced. In one or two instances a slight rise in tone was seen but was too small to be of any significance. The inhibitory action of atropine was also absent. In some cases, however, atropine seemed to exert a slight stimulating action. Fig. IV shows the effect of atropine.

On testing adrenaline no inhibition of movements could be demonstrated, but invariably stimulation resulted (Fig. IV.) A rise in tone and increased force of contractions always resulted with adequate doses of this drug. On the other hand, if the intestinal strip has become hypodynamic and lost all traces of rhythmic movements, minute quantities of adrenaline (1:60 million) will call forth slight movements. On increasing the concentration of adrenaline to 1:40 million, the movements become stronger, accompanied by a rise in tone. Raising the concentration of adrenaline still further produces spasm of the muscle, the rhythmic movements being almost entirely absent. Fig. V shows the response of a fatigued piece of stomach to different concentrations of adrenaline. The action of adrenaline on a segment of stomach contracting rhythmically is shown in Fig. IV.

The spiral or large intestine gives results identical with those obtained on the ascending limb of the stomach. Fig. VI shows, at the left, contractions obtained from a strip of large intestine and on the right, the response of the same preparation to adrenaline. Pilocarpine and atropine had no effect on the movements. The spiral valve was also tested, but no response to the drugs used above was ever obtained. Gradual changes in tone were seen in the few preparations tested. A difficulty in connection with the spiral valve is the great thickness of the mucosa which covers it on both sides and through which drugs can only penetrate with difficulty. Whether the spiral valve carries out rhythmic movements or not cannot be stated at present, but it is conceivable that it undergoes changes in tone, depending on the amount of food in the large intestine. The contractions of muscle of the large intestine surrounding the spiral valve would suffice to move the intestinal contents toward the rectum.

Having found that the sympathetic was the motor nerve in the dogfish and skate, the reaction of the intestine of some bony fish was investigated. In these the vagus turned out to be the motor nerve, judging by the reaction to pilocarpine and atropine and the sympathetic inhibitory, since adrenaline always gave rise to inhibition. Mackerel, herring, minnows (Fundulus) and pipe-fish all gave similar effects with pilocarpine, namely motor. The contractions produced by pilocarpine were inhibited by atropine. Adrenaline in all these types gave pure inhibitory effects. Fig. VII shows the action of adrenaline on the intestine of Fundulus and Figs. VIIIa and VIIIb the reaction of pipe-fish intestine to pilocarpine, atropine and adrenaline. Henderson[3] has found similar results on the stomach of these fishes.

The "Ringer" fluid used for the intestine of bony fishes was of the following composition:—NaCl 1.1%, KCl 0.055%, $CaCl_2$ 0.04%, $MgCl_2$ 0.024%, $NaHCO_3$ 0.05%.

Since there are data that the first nervous elements descending into the intestine are of parasympathetic origin (vagus), these experiments give certain indications of the different course of innervation of the alimentary canal in different animals. Gaskell[4], Abel[5] and Kunz[6] describe the vagal origin of Auerbach's plexus in the intestine of warm blooded animals, while E. Müller[7] finds a similar condition in *Squalus acanthius.*

DESCRIPTION OF FIGURES.

Fig. I. Dogfish. Ringer without Urea.
Fig. II. Dogfish. 2% Urea in Ringer.
Fig. III. Dogfish. 1% Urea in Perfusing Fluid.
A. Normal; B. Pilocarpine 1/4 mg.; C. Pilocarpine 1/4 mg.; D. Pilocarpine 1 mg.; E. Pilocarpine washed out.

Fig. IV. Dogfish. Capacity of Perfusing Bath 75 c.c.
A. Normal; B. Pilocarpine 1 mg.; C. Atropine 1 mg.; D. Adrenaline.

Fig. V. Dogfish.
A. Adrenaline 1:15M.; B. Adrenaline 1:30M; C. Adrenaline 1:60 M.; D. Adrenaline 1:40 M.

Fig. VI. Dogfish Male. Ringer containing 1% Urea.
A. Large Intestine; B. Adrenaline 1:10 M.; C. Adrenaline 1:10 M.

Fig. VII. Fundulus Small Intestine.
A. Adrenaline: B. Adrenaline.

Fig. VIII. (a) Pipefish Small Intestine.
A. Pilocarpine 1:½M.; B. Adrenaline 1:10M.; C. Pilocarpine 1:500,000; D. Atropine 1:500,000.

Fig. VIII. (b) Pipefish Small Intestine.
E. Pilocarpine 1:100,000; F. Atropine 1:100,000.

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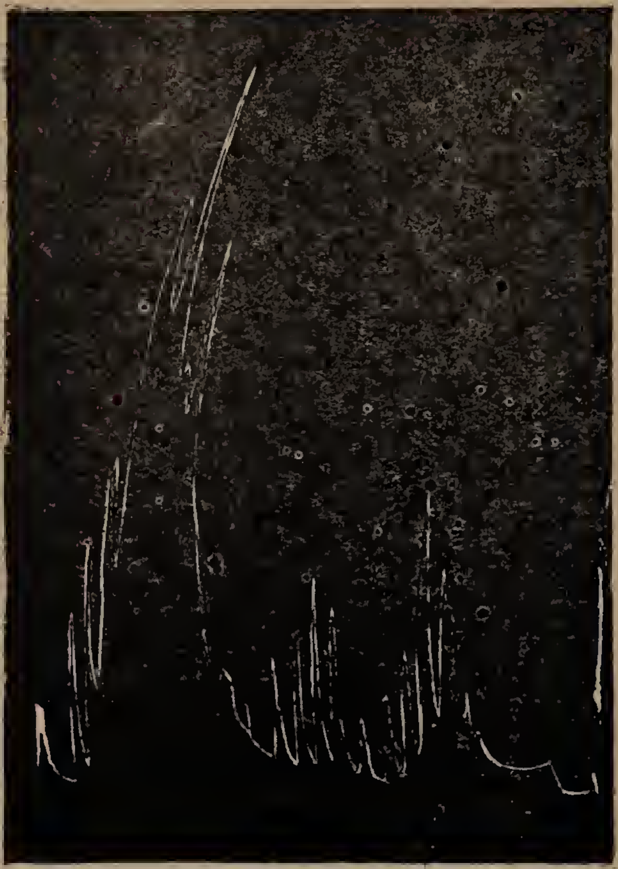

Fig. I

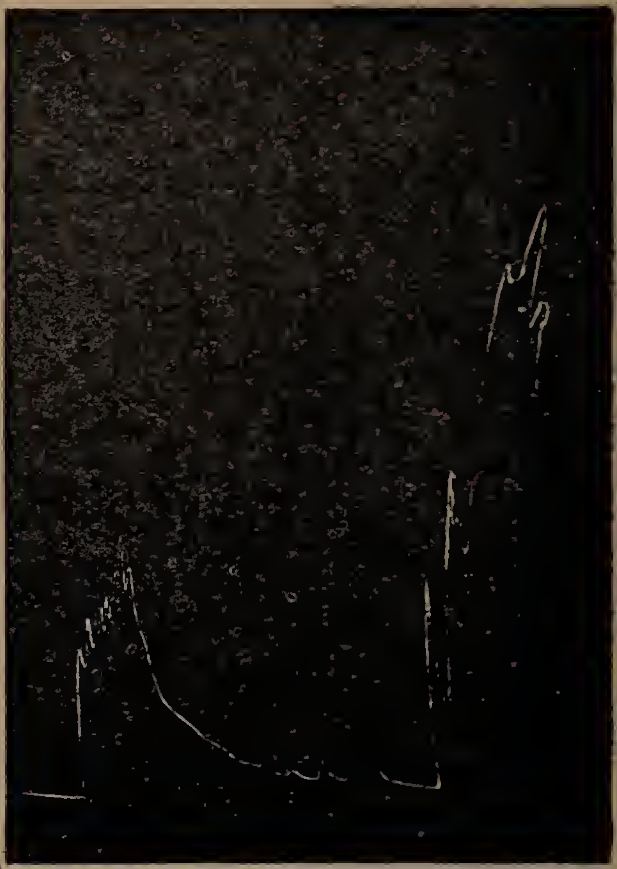

Fig. II

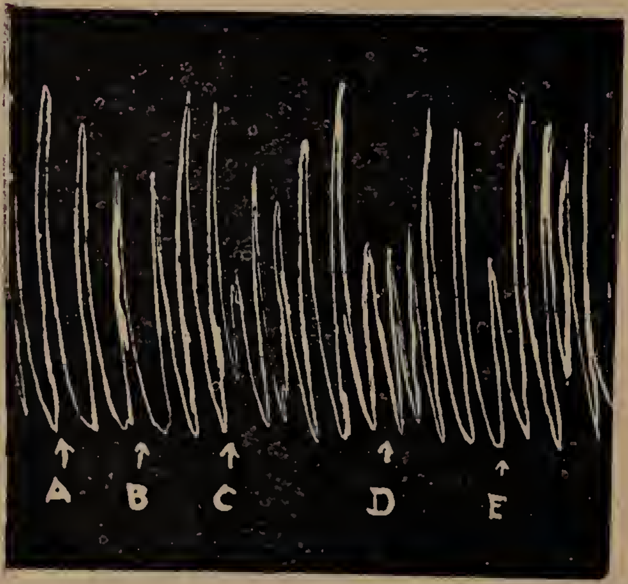

Fig. III

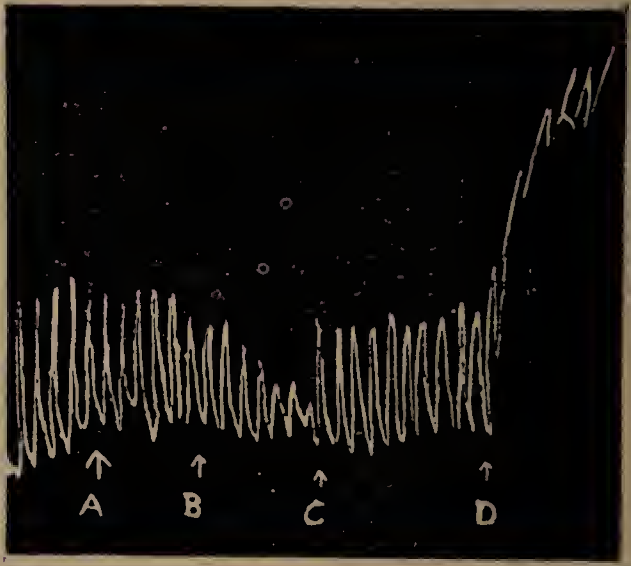

Fig. IV

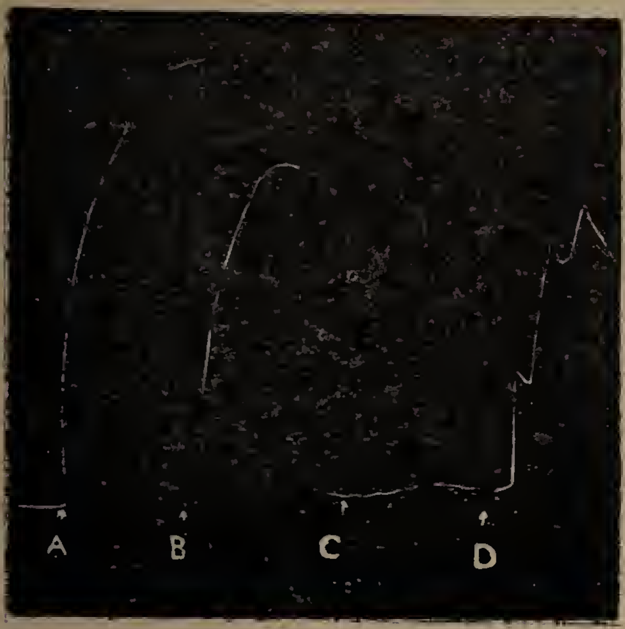

Fig. V

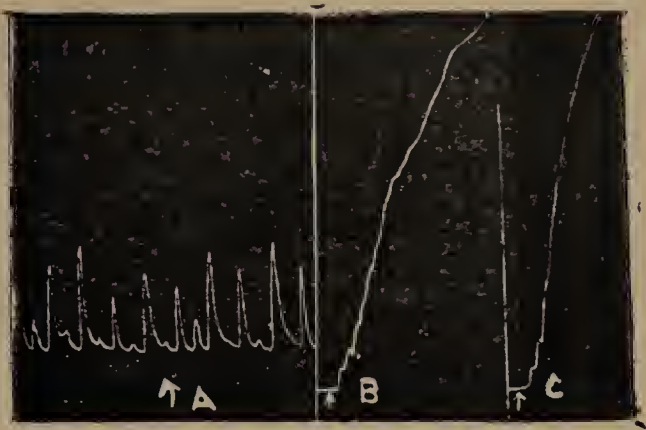

Fig. VI

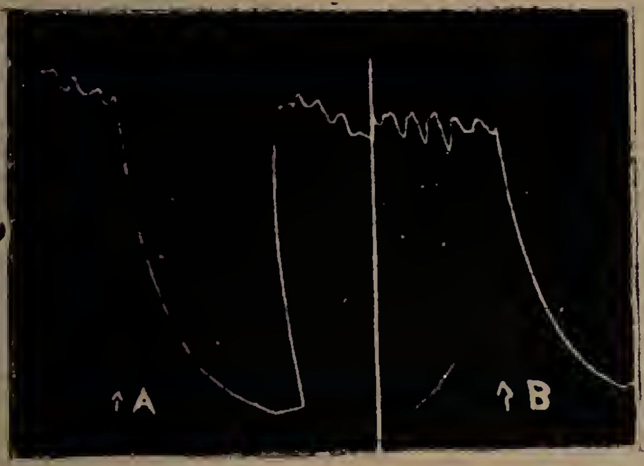

Fig. VII

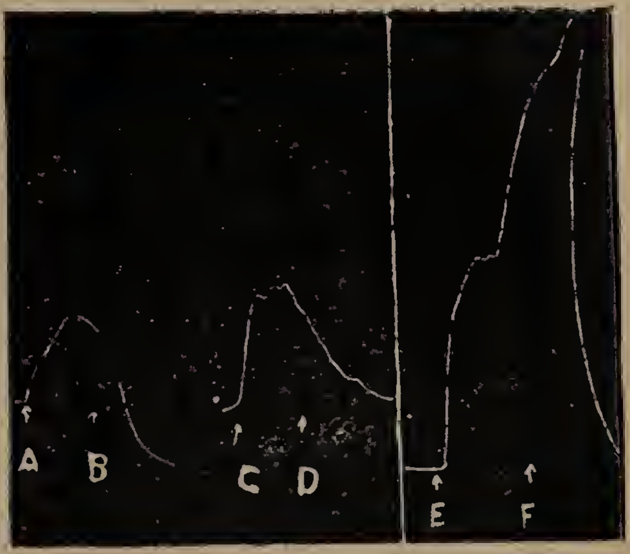

Fig. VIII

ON THE RATE OF FREEZING IN FISH MUSCLE.—By G. O. LANGSTROTH,*† McGill University.

(Presented 15 May 1929)

ABSTRACT.

The fundamental equation for the flow of heat is applied to the case of the freezing of fish muscle. The resulting equation, obtained by assuming the solution in the form of a transcendental equation and finding the constants involved from the boundary conditions, connects the time of freezing with the thickness and the thermal and physical constants. The freezing of an additional thickness, on removal from the bath, due to the redistribution of the temperature gradient, is investigated.

The problem of the flow of heat in a homogeneous body has been thoroughly worked out by different investigators, and the question of the rate of freezing has also necessarily received some attention. Neumann[1] has worked out a general expression for the rate of ice formation, in terms of the physical and thermal constants of water and ice. His method is quite general, and can be applied to cases where conditions vary over a wide range. Stefan[2] has developed a treatment by assuming certain conditions which render it only a special case of Neumann's treatment. Both these methods involve only very slight approximations, and the resulting equation in series form can be made to hold to almost any desired degree of accuracy. King[3] has treated the problem from the standpoint of the progress of frost into concrete, by assuming a linear temperature gradient throughout the frozen material[4]. This introduces only a small error (about 4%), and simplifies the procedure enormously.

The following treatment of the problem of the rate of freezing of fish muscle will follow that given by Stefan for ice formation.

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*National Research Bursary.
†Fisheries Exp. Sta. (Atlantic) Halifax, N. S.

[1] Franz Neumann, Weber-Riemann, "Part. Diff. Gleichungen".
[2] J. Stefan, Wied. Ann. 42. 269.
[3] L. V. King, Proc. Roy. Soc. Canada. 3. 12. 1918.
[4] See also Barnes, "Ice Engineering".
For a short discussion of Neumann's and Stefan's methods see Ingersoll and Zobel, "Math. Theory of Heat Conduction".

Let us impose the following conditions in order to simplify the problem. Consider a block of fish with one surface in contact with a bath at temperature T. Let it be just at the freezing temperature, but not frozen at the time $t=o$. Let the temperature scale be so chosen that the zero is at the freezing point of the fish, and let us assume that the block is large enough so that the edge effects may be neglected. The freezing starts immediately and the heat is conducted only through the frozen material.

Let the following symbols apply to the frozen material, k the specific conductivity, c the specific heat, θ the temperature at any point in the frozen material at time t, and ρ the density. Let L be the latent heat of the fish, T the temperature of the bath, ϵ the distance of the "freezing edge" from the bath, ρ' the density of the unfrozen fish, and x the coordinate of any point measured from the edge of the bath.

The fundamental equation for the flow of heat may be written,

$$h^2\Delta^2\theta=\partial\theta/\partial t \quad \text{where} \quad h^2= \quad k/c\rho.$$

When we consider flow of heat in one direction only we may write $\partial\theta/\partial t=h^2\partial^2\theta/\partial x^2$ (1)

Assume as a solution of this equation some expression of the form,

$$\theta=A\int_{x/2h\sqrt{t}}^{\beta} e^{-z^2}\,dz \tag{2}$$

which can be shown to be a particular solution of the linear Fourier equation, (1).

It now remains so to adjust the constants "A" and "β" that the equation is consistent with the boundary conditions.

The boundary conditions which must be satisfied are as follows,

(a)...... $k(\partial\theta/\partial x)_{x=\epsilon}=L\rho' d\epsilon/dt$

(b)......when $\theta=T,\quad x=o$

(c)......when $\theta=o,\quad x=\epsilon$

(d)...... $\partial\epsilon/\partial t= -(\partial\theta/\partial t/\partial\theta/\partial x)_{x=\epsilon}$

Condition (a) arises from a consideration of the material at the freezing edge, i. e.

Heat given out by layer in freezing $= L\rho' d\epsilon$ per cm^2.

Heat conducted away in a time $dt = k(\partial\theta/\partial x)_{x=\epsilon}\ dt$

If we neglect the second order effect due to the establishing of a temperature gradient in the thickness *dx* which would add another term to the last equation given, we have

$$k(\partial\theta/\partial x)_{x=\epsilon} = L\rho' d\epsilon/dt \qquad (3)$$

Condition (d) follows at once from the fact that we may

write $\theta = f(x, t)$

and hence $d\theta = \partial\theta/\partial x . dx + \partial\theta/\partial t \cdot dt.$

But when $x = \epsilon,\ d\theta = o$

Therefore, $d\epsilon/dt = -(\partial\theta/\partial t/\partial\theta/\partial x)_{x=\epsilon}$

which is condition (d).

We may now combine conditions (a) and (d) to give the equation

$$(\partial\theta/\partial t)_{x=\epsilon} = -k/L\rho' . (\partial\theta/\partial x)^2_{x=\epsilon} \qquad (4)$$

If we differentiate the solution as given by (2), with respect to *x* and *t*, we obtain

$$(\partial\theta/\partial t) = Ae^{-x^2/4h^2t} \cdot x/4ht^{3/2} \qquad (5)$$

$$(\partial\theta/\partial x) = -Ae^{-x^2/4h^2t} \cdot 1/2ht^{\frac{1}{2}} \qquad (6)$$

When we apply condition (c) to equation (2) we see that at $x = \epsilon$, since the integral vanishes, the limits must be equal, and

$$\beta = \frac{\epsilon}{2h\sqrt{t}} \qquad (7)$$

Substitute this value in (5) and (6) and we obtain

$$(\partial\theta/\partial x)_{x=\epsilon} = Ae^{-\beta^2} . \beta/2t \qquad (8)$$

$$(\partial\theta/\partial x)_{x=\epsilon} = Ae^{-\beta^2} \cdot 1/2h\sqrt{t} \qquad (9)$$

Substitute these values in (4),

$$Ae^{-\beta^2}\beta/2t = -k/L\rho' \cdot A^2e^{-2\beta^2} \cdot 1/4h^2t \qquad (10)$$

From which "A" is given as,

$$A = -2L\rho'h^2/k \cdot \beta e^{\beta^2} \qquad (11)$$

Now condition (b) is a particular case of (2) which we may write

$$T = A\int_0^\beta e^{-z^2}\,dz. \qquad \text{i. e.} \quad \beta e^{\beta^2}\int_0^\beta e^{-z^2}\,dz = -kT/2L\rho'h^2 \qquad (11a)$$

This expression can be easily expanded and integrated and becomes

$$-kT/2L\rho'h^2 = \beta^2[1+2/3\cdot\beta^2+4/15\cdot\beta^4 \ldots\ldots\ldots\ldots] \qquad (12)$$

Putting in the value of (β) from (7),

$$-kT/2L\rho'h^2 = \epsilon^2/4h^2t.\ (1+2/3\cdot\epsilon^2/4h^2t + 4/15\cdot\epsilon^4/16h^4t^2 \ldots\ldots)$$

which gives the relation between the time "*t*" and the thickness ϵ of the material frozen.

To a first approximation this becomes

$$\epsilon^2 = -2kTt/L\rho' \qquad (13)$$

while if only powers of ϵ^2/t greater than the third are neglected we get

$$-kT/2L\rho' = \epsilon^2/4t + 2/3\cdot\epsilon^4c\rho/16kt^2 + 4/15\cdot\epsilon^6c^2\rho^2/64k^2t^3 \ldots \qquad (14)$$

These equations give the rate of freezing for the conditions named. The effect of experimental boundary conditions will cause a slight discrepancy probably, and for that reason the above will give an upper limit for the time. Note that (13) corresponds to the assumption of a linear temperature gradient The error introduced is of the order of 4%.

Using the following values for the constants of the fish, and the first approximation equation (13), the thickness which is frozen under different conditions is calculated.

L......................60 cal/gm.[1]
k......................0.0014 cal/°C. sec. cm.[2]
ρ'....................0.8 gms/cm.^{3}

---

1. Chipman and Langstroth .... Trans. N. S. Inst. Sci. XVII, Part 3, p. 175, 1929.
2. Langstroth..............................Fish. Exp. Sta. (Atlantic) Report, 1928.

TABLE I.

T.(C°)	ϵ(cm.)	t (hours)
-10	1.0	0.48
-10	2.0	1.90
-10	3.0	4.28
-10	4.0	7.60
- 5	1.0	0.96
- 5	2.0	3.80
- 5	3.0	9.56
- 5	4.0	15.2

These values should not be taken as representing actual fact, in that the values for the constants have not all been accurately determined. The value of ρ' is a purely assumed one since, as far as the author knows, no measurements have been made along these lines. The value assumed for k is one based on some preliminary work done in 1928 over the range 25°-100°. The effect of boundary conditions is probably slight in freezing under practical conditions using methods such as are now in use at the Experimental Fisheries Station, at Halifax, N. S.

The following points should also be noted,

1. If the freezing takes place from both sides then the thickness frozen in a given time is just four times that given by (13).

2. The temperature scale used is one which has its zero at the freezing point of the fish muscle.

An interesting case arises when we consider what happens when a piece of fish is removed from the bath before it is entirely frozen. For convenience assume that on removal from the bath the amount of heat passing to, or from, the surroundings is negligible for a short length of time. Under these conditions the equalization of the temperature throughout the medium provides the sink necessary for the disposal of the small amount of heat liberated in freezing the narrow strip of material which did not freeze in the bath.

The expression for the temperature anywhere through the frozen material is given by (2) i. e.

$$\theta=A\int_{x/2h\sqrt{t}}^{\beta} e^{-z^2}\,dz.$$

We have also the special case as given by (11a)

$$T=A\int_{o}^{\beta} e^{-z^2} dz$$

The constants have been determined for both these equations and are given by (7) and (11). We then arrive at the expression

$$\theta - T=A\int_{x/m}^{\beta} e^{-z^2} dz - A\int_{o}^{\beta} e^{-z^2} dz$$

where "m" $=2h\sqrt{t}$

Hence, $$\theta - T=A\int_{x/m}^{o} e^{-z^2} dz \qquad (15)$$

Expanding and integrating,

$$\theta - T= - A[x/m - x^3/3m^3+x^5/10m^5..........] \qquad (16)$$

The conditions under which a thickness *d* will freeze after removal from the bath are obviously given by the equation,

$$\int_{o}^{\epsilon} (o-\theta)\ \rho c\ dx=L\rho' d.$$

This becomes on substitution from (16)

$$T\epsilon - A\epsilon^2/2m+A\epsilon^4/12m^3 - A\epsilon^6/60m^5.......=L\rho' d/\rho c$$

This becomes on substitution for "*A*" from (11)

$$T\epsilon+L\rho' h^2/k.\ \epsilon^2/m\cdot \beta(1+\beta^2+\beta^4/2..) - L\rho' h^2/6k\cdot \epsilon^4/m^3\cdot\beta(1+\beta^3+\beta^4/2 .... +L\rho\ h^2/30k\cdot \epsilon^6/m^5\cdot \beta(1+\beta^2+\beta^4/2....)=L\rho' d/\rho c.$$

Neglecting terms in β^5 and substituting from (7)

$$T\epsilon+L\rho' h^2/k\cdot \epsilon^3/4h^2t+5/96\cdot L\rho' h^2/k\cdot \epsilon^5/h^4t^2 - 1/480\cdot L\rho' h^3/k.\ \epsilon^7/h^6t^3......=L\rho' d/\rho c$$

or,

$$T\epsilon+L\rho'/k.\ \epsilon_3/4t+5/96.\ L\rho'\rho c/k^2.\ \epsilon^5/t^2 - 1/480.\ L\rho'\rho^2c^2/k^3.\ \epsilon^7/t_3.... =L\rho' d/\rho c \qquad (18)$$

which is the equation giving the thickness *d* of material which will be frozen after removal from the bath. Elimination of *t* or ϵ between equations (18) and (14) gives *d* as a function of ϵ or *t*, as may be desired.

To a first approximation, using (18) and (13),

$$T/2\cdot \rho c\epsilon/L\rho' = d \qquad (19)$$

This is what we would expect from an assumption of a uniform temperature gradient throughout the frozen material. Equation (19) is quite accurate enough for any practical work on account of the small size of the effect with bath temperatures of -15°C or so. A glance at the equation (19) will show, however, that the effect increases with the temperature difference between the bath and the freezing point of the fish. Some idea of its magnitude may be obtained from the fact that with a bath temperature at -10°C. and a thickness of 4 cm. frozen before removal, an additional thickness of approximately 0.2 cm. would freeze after removal.

What has been said of (13) and (14) applies here also. In addition there is the assumption of no heat transfer to or from the surroundings, for the short period of time which is required for the material to come to equilibrium. This is probably not a very dangerous one, when the fish are kept piled together in a room at storage temperature. The effect might become important if very low freezing temperatures such as that obtained with solid Carbon-dioxide were used.

The author wishes to thank Dr. L. V. King for his interest in the matter and for checking the results.

Author's Note:—This treatment has recently been tested experimentally and has been found to hold to the degree of accuracy of the experimental method. Conductivities are of the order of .0024 cal/°C–sec .cm for the frozen muscle.

Sept. 17th, 1929.

The attention of members of the Institute presenting communications for publication is directed to the following notes.

1. Fifty "separates" of each communication accepted by the Council for publication are provided for the author.

2. Drawings which have to be reduced in size should have the lines and letters sufficiently large to be distinctly visible in the print. The drawings should be about double the size of the proposed print. The copy should be carefully typed or in distinct manuscript.

3. The nomenclature of species, etc., should be given in good form, such as is recommended by the authorities directing the abstracting of scientific literature.

4. References to previous or other papers should be made clearly and neatly in the forms approved as in 3. They should be grouped together for insertion at the end of the article.

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THE

PROCEEDINGS AND TRANSACTIONS

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TRANSACTIONS

OF THE

Nova Scotian Institute of Science

SESSION OF 1929-30
(Vol. XVII, Part IV)

THE ACADIAN-NEWFOUNDLAND EARTHQUAKE.

—By D. S. McINTOSH, M.Sc., Department of Geology, Dalhousie University, Halifax, N. S.

(Presented 12 February 1930).

ABSTRACT.

The cable breaks on the ocean floor all occurred in the embayment of the North Atlantic between the New England-Nova Scotian fishing grounds and the Grand Banks of Newfoundland. The numerous breaks spread over a large area resulted from displacements of the sea bottom—vertical, and perhaps horizontal. The disturbed portion is in a line with the old submerged channel of the St. Lawrence river and it is probable that a settling of the sediments accumulated seaward from the river's mouth was the primary cause of the earthquake. The land region to the north has as a basement very old rock which must have a large degree of stability, but which through the past has at various times been subjected to earth movements. The loss of life and property at Burin, Newfoundland, the expense of repairing cables and the inconveniences to which the Cable Companies were put, and the minor effects that show the intensity of the shock are stated as a matter of record.

INTRODUCTION.

As a matter of scientific interest, it is desirable that the Nova Scotian Institute of Science should have placed upon its records an account of the recent earthquake which was felt through parts of the New England States, the Maritime Provinces and Southern Newfoundland. Nearness to the seat of disturbance makes it of especial interest to Nova Scotians and the disastrous effects in Newfoundland place it in the category of the lesser major earthquakes.

General Remarks.

The earthquake shock occurred at 4h. 32m. 8s. o'clock on the afternoon of November 18, 1929. It was felt within a radius of some hundreds of miles from the seat of disturbance on the ocean floor in the embayment of the North Atlantic between the New England-Nova Scotian fishing grounds and the Grand Banks of Newfoundland. The submarine area affected lies, in a rough way, between 52° and 58° West Longitude and 38° and 46° North Latitude, embracing an extent of territory approximating a hundred thousand square miles. Although this whole area suffered from the shock, there appears to have been greater intensity towards the north of the region for there the epicentre—the surface directly overlying the break— has been located by the scientists in charge of the seismographs at Dalhousie, Ottawa, Harvard, and Washington. The immediate effect of the shock was to put out of commission the telegraph cables crossing the area. A score or so of breaks in the cables were found by the repair ships that were dispatched at once to the disturbed area. The general report of the officers in charge of repair work is that the soundings where cable breaks occurred showed no appreciable difference from the charted depths. Any small disparity might be explained by original error in depth-taking. Nevertheless, the fact that a sea-wave was generated by the disturbance shows that there was vertical displacement on the ocean floor. The force that had to be exerted in lifting broken cables in certain places made it evident to those in charge of the work that the cables were buried under a mass of material that had apparently slid down a slope. The small number of depths marked on available charts of the locality make it impossible to know if any steep slopes are present on the sea bottom at this place. That such exist is not improbable. There may have been horizontal as well as vertical displacement. The depths in which cables were broken ranged from 44 to 2934 fathoms.

Effects of the Quake.

Phenomena accompanying disturbances on the sea bottom have often been described. The rock movements propagate waves that travel through the overlying and adjacent waters. These vibrations are often felt by ships at sea. On this occasion the Captain of the S.S. Caledonia of the Cunard Line states that on November 18 at 3:30 p. m. Eastern Standard Time, the shock was felt on shipboard. A message sent from the ship at sea reads:—"44°26′ North Latitude, 57°4′ West Longitude experienced earthquake shock causing ship violent vibrations for two minutes. No apparent damage." The ship's position at that time was quite close to the epicentre.

Sea waves whose dimensions vary with the intensity of the shock are an accompaniment of submarine earthquakes. In general, the disturbed waters are seen to recede from the land and then return often with destructive force. About two hours after the shock under consideration a sea-wave rolled from the ocean upon the Newfoundland and Cape Breton coast line. At Burin the usual recession of the water preceded the advance wave. Great destruction was wrought along the coast of southern Newfoundland in the Burin peninsula. About fifty miles of the south and eastern coastline from Lamaline on the south to Rock Harbour well up the peninsula on the east side was swept by a wave fifteen feet high. Waterside buildings—stores and dwellings,—fishing stands, boats, dories and skiffs were swept away with great loss of provisions, coal, etc. A small schooner was left stranded by the receding waters. One building swept seaward remained anchored in the sea. The worst feature of all was the loss of twenty-six lives. As a result, a pall of sadness hangs over the sparsely settled fishing communities along the Burin coast.

The wave struck the Nova Scotian shore also. At Canso a 28 ton schooner was swept from her moorings at a wharf at eight o'clock and later drifted ashore. The water at Sydney rose five feet above a maximum high tide; and at North Sydney about half-past eight o'clock over a foot of water covered the docks, and small boats floated near the business houses on Commercial Street, the water here having advanced on the land about two hundred yards.

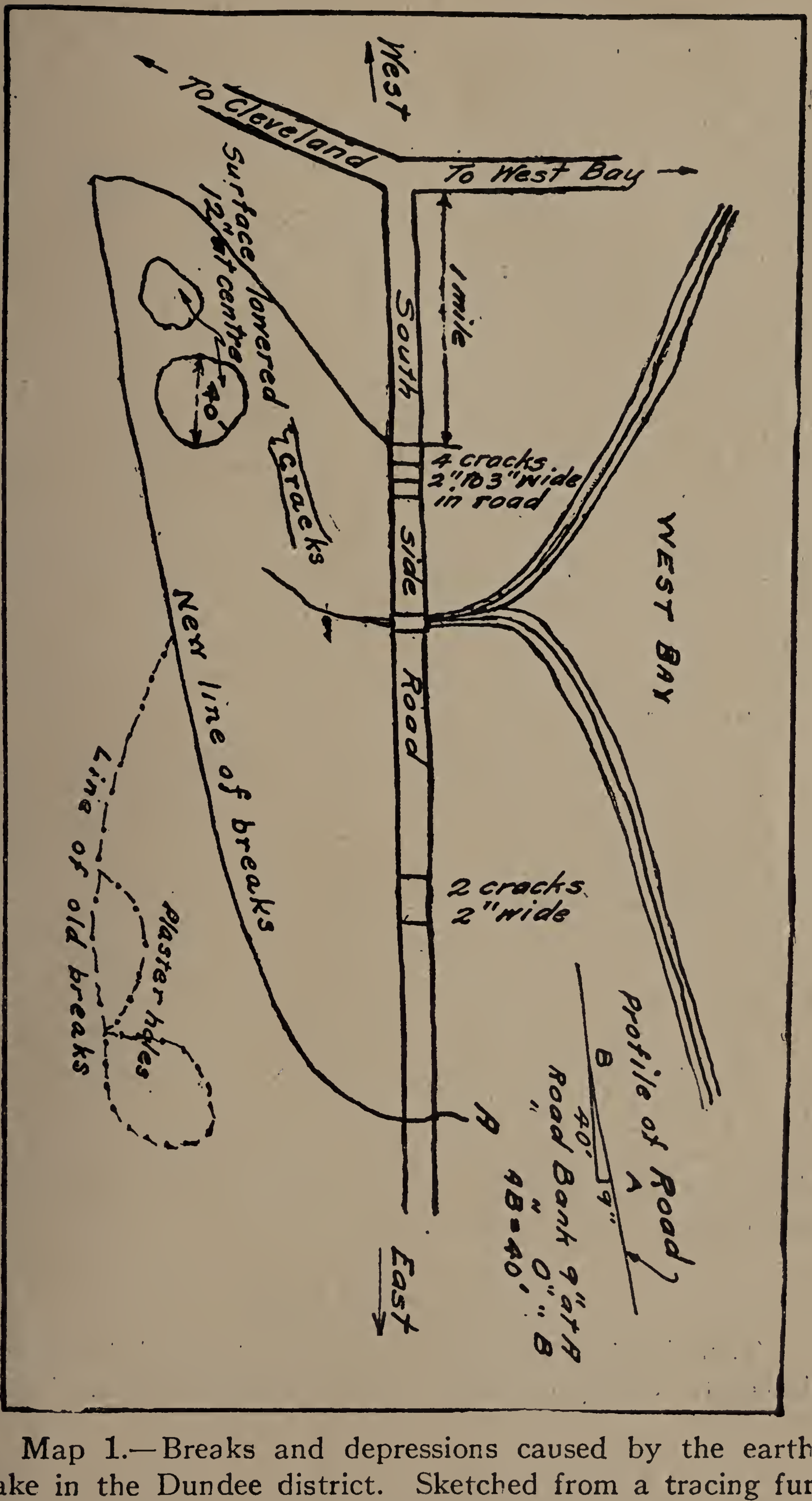
All through the Province of Nova Scotia there was felt a distinct shock. It was accompanied by a peculiar noise that many people took to be furnace trouble in the basements of their dwellings. Added to this was the noise of moving objects. Doors and windows rattled, buildings shook and trembled, dishes rattled in the cupboards, and pictures swung out from the wall. From some localities are reported falling chimneys. Several cases are reported of objects stopping when just about to topple over. At Whitney Pier it is said the water of a well became roiled.

In two places in Cape Breton Island the road was damaged. Near Ross' Ferry at Boulardarie there was a landslide from the slope down upon the road. Here the underlying rock is gypsum which is often unstable and easily displaced by a movement such as an earthquake. At Dundee, Richmond County, which is also a gypsum district, several breaks occurred in the road and adjacent land where new plaster holes were made. On the main road in a distance of about two and a half miles there are seven breaks two to three inches wide extending only across the roadbed. The most easterly one had a vertical displacement of nine inches hinging at a distance of forty feet to the west. A similar explanation applied to this district as in the Ross' Ferry case. In general it would seem that gypsum districts suffered more than places underlain by more solid rock. Windsor fared worse than Halifax.

The Adjacent Land Mass.

It has been customary, and will continue to be so, to speak of Northeastern North America as a region of crustal stability. The reason is evident: the basement of the region, the Canadian Shield, Southeastern Quebec, and Cape Breton Island, is largely of Archaean rock, the oldest on the continent, and it is highly probable that the same rock prevails underneath the adjacent areas. Upon this has been built the less old, and much younger rocks. Such a condition gives stability to the whole territory.

While it is true that earth disturbances have not much affected the whole region since early geological time, the records of the rocks show that portions of the region have



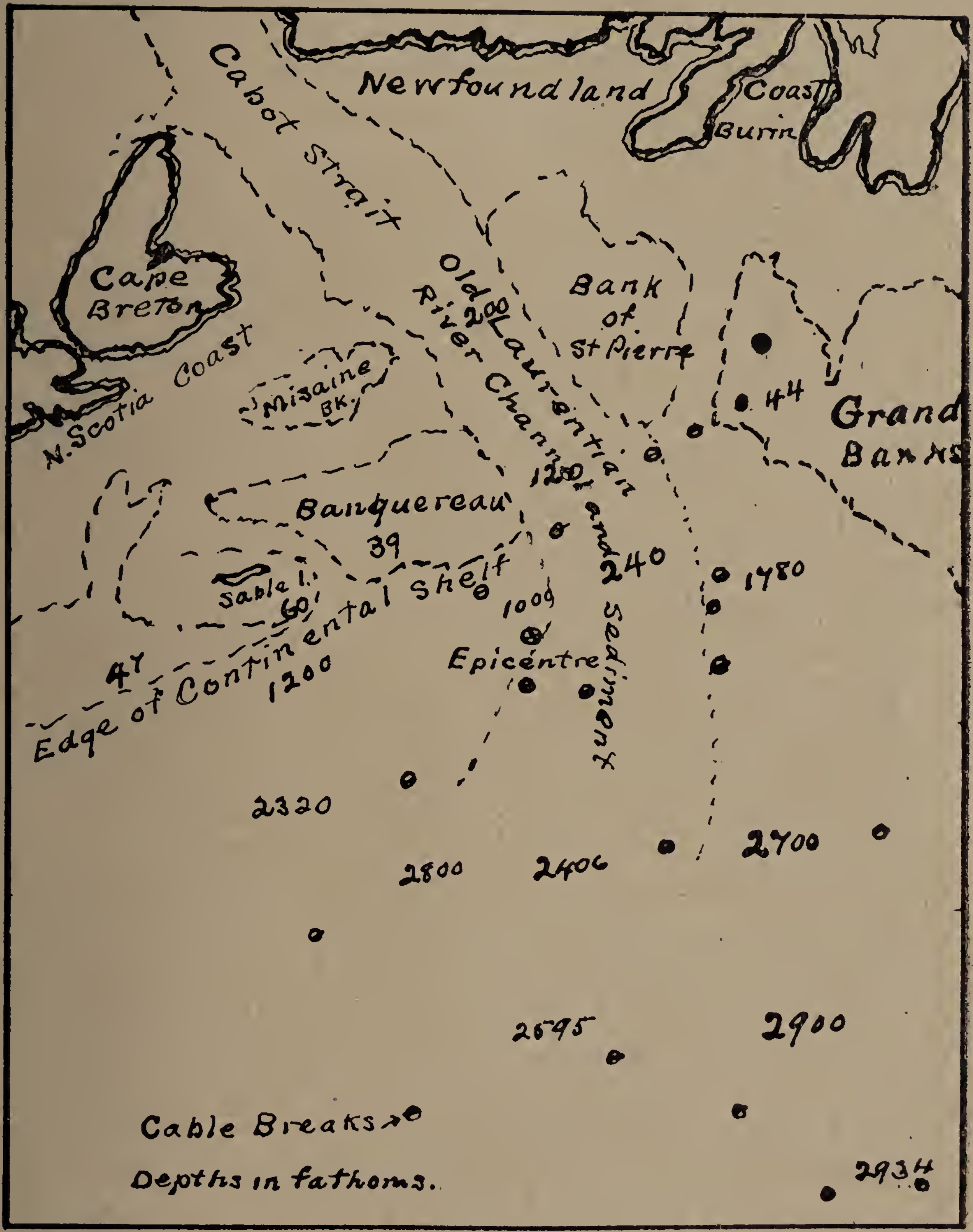
Map 1.—Breaks and depressions caused by the earthquake in the Dundee district. Sketched from a tracing furnished by the Nova Scotia Highway Board.

been subjected at various times in its long history to earth movements of great magnitude, and of long or short duration. The rock of the land mass that makes up the southeastern coastline of Nova Scotia and in all probability extends to the edge of the continental shelf is quartzite and slate surrounding granite areas. In Southeastern Newfoundland are rocks that in many respects resemble the Nova Scotian altered sedimentaries and may be of the same age. This Gold Measures Series of Nova Scotia has a thickness of over six miles which accumulated in a long trough-like depression extending from the western end of the Province to possibly the southeastern end of Newfoundland. Here was a zone of weakness. As the sediment grew in thickness the bottom kept sinking until the earliest formed sediment was miles below the surface and then the whole mass yielded to pressure from the ocean bottom and was folded into mountain ranges of Alpine height. This was some time later invaded by upwelling molten rock which solidified to make the Nova Scotia granite. These events were of revolutionary magnitude as earth movements.

Besides mountain building and intrusion of igneous material, there have been times in which stresses were relieved by rock fracture. There is in the St. Lawrence estuary the great Champlain fault; along the north shore of the Bay of Fundy is the Fundian, and associated faults; the Chedabucto fault is not far removed from the recently disturbed area; and there are numerous transverse faults that have cut across the Gold Measures Series and that have disturbed the rocks and the seams in various coal fields. There have been, also, regional uplifts and subsidences. The present coastline is a sunken one, the sea having invaded the lower courses of the rivers. The sinking was, however, followed by coastal stability, and it is highly probable that that condition continues, and has been such for some hundreds of years.

The Submarine Areas.

There is a fine development of the continental shelf around the coast. Off the Nova Scotia shore it extends seaward about



Map 2.—Map of the earthquake region and adjacent land and submarine areas.

125 miles, ending in 80 to 100 fathoms of water. From Burin to the south end of the St. Pierre bank is about 200 miles. The area of the Grand Banks is much more extensive. Over the continental shelf bottom are the Banks—shallower water averaging about 50 fathoms with depressions of greater depths. This continental shelf is, according to Dr. Goldthwait, the drowned portion of a peneplane, the landward part of which may be seen as a dissected inclined plane stretching over the New England States and the Maritime Provinces. The Banks are erosion remnants and the depressions are the result of stream action.

The continuity of the continental shelf is broken between the Nova Scotian banks and the St. Pierre banks where for a width of about sixty miles the water deepens to over 200 fathoms. This deeper-water belt beginning at the edge of the shelf extends through the Cabot Strait and with diminishing width and depth along the floor of the Gulf of St. Lawrence, and curving around the Gaspe′ peninsula it occupies the estuary of the St. Lawrence river. At the margin of the shelf, the water on either side has a depth of but 60 to 75 fathoms. This depression is undoubtedly the submerged channel of an old river whose head waters were somewhere in the Upper Great Lakes. Dr. Young describes this "hypothetical stream," the old Laurentian river, as cutting its course across from Georgian Bay to near Toronto—a pre-glacial stream.[1] If the direction of the course of this submerged channel be extended seaward, there is apparently found a flat "rise" that may be traced down towards the 40th parallel. For seventy miles from the mouth of the old river there is apparently very little drop in the slope. Recent soundings by the S. S. 'Faraday" at 44°50′ north and 56°20′ west gave a depth of 240 fathoms. Beyond this point the slope becomes steeper; and about 60 miles to the east there is a depth of 2100 fathoms. The drainage basin of the old Laurentian river was extensive, probably as great or greater than that of the present St. Lawrence river; the volume of water was great enough to cut a course 60 miles wide at its mouth with banks at the side of 800 feet or so in height. The sediment carried and deposited by this great volume of water must be the ocean "rise" that extends southward from the old stream's mouth and is spread out in somewhat delta form. Settling of this mass of sediments would account for the breaks in the cables in the northern portion of the region, and the disturbance might also be communicated to points further south and all through the shattered area by fractured sub-strata.

---

[1] A larger map of the region is seen in Dr. Johnstone's paper, and may be consulted. These Transactions, **17**, Pt. 4, 231, (1930).

Nowhere around the continental shelf from its edge to the ocean floor with depths of 2500 to 3000 fathoms is the slope steep, one in twelve to one in forty feet. There are apparently no declivities along the continental slope.

Another point of interest about the continental shelf is that there extends from Burin southwards to near the epicentre, as located by Dr. Keith, a depression about 25 miles wide with water about 30 fathoms deeper than that on either side. Apparently along this course the sea wave swept northward working such havoc on the Burin peninsula. Elsewhere its effect was lessened by the shallower water.

Several specimens of material from the sea bottom were obtained through the courtesy of officers of the "Faraday", "Cyrus Field," "Lord Kelvin" and "John W. Mackay." They ranged in locality from 42°30′ North to 44°50′, and from 54°58′ West to 56°20′. Most of the samples were clays with just sufficient calcareous material to produce effervescence with weak acid. Evidently the area is north of the forameniferal ooze belt. Dr. Keith, of the National Research Council at Washington, is having an analysis made of samples of these clays; and Dr. Kindle, of the Geological Survey at Ottawa, is having them examined for foramenifera. There was also recovered from a depth of 2100 fathoms pebbles of considerable size mixed with clay. From the depth of 240 fathoms previously referred to, large sized pebbles were obtained, chiefly igneous material, some of the pebbles showing glaciated surfaces.

The earthquake of the 18th of November is discussed from the seismological standpoint in a paper by Dr. J. H. L.

Johnstone who has charge of the seismograph at Dalhousie University.

CONCLUSIONS.

The old Laurentian river with its huge volume of water, its deeply trenched and broad course, the tremendous amount of rock waste carried from its bed and basin, and the evident presence of a great mass of debris seaward from its mouth appears to the present writer to furnish a case somewhat analogous to that of the Mississippi valley previous to 1811. Settling and fracturing of the thick mass of sediment concealed beneath the waters of the embayment is therefore put forward as a tentative cause of the recent earthquake. Besides the stream-borne material there is also the probability of much glacial drift lying upon the sea bottom. Cable breaks spread over such a large area point to several faults, not to one major fault. This would tend to make the recurrence of earthquakes of some magnitude less likely in this region; and, on account of the stable structural features of the country, freedom from major disturbances should continue to afford a large measure of satisfaction to the inhabitants along the seaboard as well as inland.

The above paper is the result of the application of well known geological principles, a probable cause for the recent earthquake being deduced from certain physical features shown on the maps and charts of the region studied. Among publications consulted should be mentioned—"The Gold Measures of Nova Scotia" by W. Malcolm; "Physiography of Nova Scotia" by J. W. Goldthwait, "The New England-Acadian Shoreline" by Douglas Johnson, and "Geology and Economic Minerals of Canada" by G. A. Young. The writer is under obligation to J. H. L. Johnstone who was indefatigable in collecting facts relating to the earthquake, and who generously passed them on to a colleague.

THE ACADIAN-NEWFOUNDLAND EARTHQUAKE OF NOVEMBER 18, 1929.—By J. H. L. JOHNSTONE, PH.D., Department of Physics, Dalhousie University, Halifax, N. S.

(Presented 12 February 1930).

ABSTRACT.

Field data obtained by some observers in Nova Scotia and Newfoundland are given. The seismograms of three of the aftershocks recorded at Halifax are discussed. The first part of the P Wave to reach Halifax was a compression. The seismogram obtained at the Island of St. Helena is briefly referred to. The Tsunami or tidal wave caused by the earthquake is discussed and a copy of the tide gauge record obtained at Halifax is shown. The damage to cables is briefly discussed and photographs of broken cable ends found at N. Lat. 43°26′54″ and W. Long. 56°12′54″ are given. No exhaustive investigation has been undertaken as this is being carried out by the Dominion Observatory, Ottawa, and by the United States Coast and Geodetic Survey.

There are records that 325 earthquakes[1] have occurred in Northeastern United States and Eastern Canada in the period 1638-1929. According to Heck[2], 104 were of intensity 5 or greater, (Rossi-Forrel scale). The epicentres occur in the region N. Lat. 40°.6 to 47°.6 and W. Long 64°.8 to 79°.6. Seven of the earthquakes, viz. those of 1663, 1732, 1755, 1791, 1860, 1870 and 1925 had intensities from 8 to 10. It is probable that eighteen of these tremors were felt in Nova Scotia and New Brunswick. An earthquake of intensity 7 to 8 was felt in New Brunswick, Nova Scotia and Maine on Feb. 8, 1855, being most noticeable at Moncton, N. B. and Dorchester, N. B.; the epicentre is placed at N. Lat. 46°.2 and W. Long 64°.8. Five epicentres have been located at N. Lat. 45° and W. Long. 67°.2 approx., (near Maine and N. B. border). Information concerning the earthquake of March 21, 1904 is published in these Transactions[3].

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[1] Hodgson, *Trans. Roy. Soc. Can.*, **4**, 151, (1927).

[2] Heck. *Earthquake History of U. S.*, U. S. Coast and Geodetic Survey Serial publication No. **149**, 13.

[3] Woodman, *These Transactions*, **11**, Pt. 2, 227 (1904).

FIELD DATA.

Halifax, N. S.—The writer, who was on the first floor of his residence, felt the house vibrate at 4:34 p. m. A.S.T. At first the motion seemed to be caused by the vibration of the engine of a motor truck near the house. The intensity of the vibration then increased, and it seemed to become more vertical in direction, as if originating in the basement of the house. It felt as if the water in the furnace were boiling with much bumping, and "water hammer" effects. The time of maximum motion was noted to be 4:34±20 seconds, A.S.T. Similar sensations were experienced by many in Halifax. Several people in the Science Building at Dalhousie University thought that the fan motors on the top floor had become loose and were bumping around. Several stenographers who were on the upper floors of the Metropole Building felt the building sway from side to side and rushed down the stairs to the street in semi-panic. The rattling of dishes and water pipes was general throughout the City of Halifax. At about 5 p. m. a strong southeast wind commenced to blow accompanied by rain and sleet; this continued until after midnight and caused interruption of the City light service. There is no evidence that any chimneys were broken in Halifax or vicinity. The barometer and thermometer readings at Halifax on Nov. 17, 18 and 19 are shown in Table V.

Lunenburg.—The buildings shook as though some heavy printing press was being operated. Radiators shook.

Bridgewater.– Fire bell rang. Several parked autos moved a few feet on the road.

Yarmouth.—Small articles were dislodged and broken. People on the street did not notice the vibration.

Annapolis Royal.—Pictures swayed from side to side. Buildings trembled. A rumbling sound was heard.

Windsor.—Chimneys were noted swaying from side to side. Two distinct shocks were noticed. The second shock was the more intense. The tops of chimneys seven feet high seemed to sway six or seven inches. Charles Scott, Esq., Head Master at King's Collegiate School, states that a chimney about seven feet high was broken through entirely, the bricks side stepping about 1½ inches in a direction approx. 30° east of south. On the following day this chimney had to be entirely demolished as it was unsafe. Aftershocks were felt at Windsor at approximately 7 p. m. and 10 p. m.

Wolfville.—Movement was more violent here than in Halifax according to reports.

Canso.—Mr. H. A. Rice reports as follows: "I was in my office which is on the end of the wharf. It seemed as though a large steamer had bumped into the wharf and the bumping continued as though the engine and propeller were still going.

Pictou.—Dishes rattled and a stove moved. A low rumbling sound was heard. People on the street did not hear it. A car with brakes on rocked back and forward terrifying the occupant. A stove and stove-pipe was seen in vibration.

Dundee, Richmond County, N. S.—A road was cracked in several places. This is discussed by D. S. McIntosh[4].

Ross Ferry, C. B.—A slight landslide occurred.

Ingonish, C. B.—Simon Brewer reports having seen two cups upset on the table and further states that a window glass was broken. A concrete door sill was put out of alignment so the door did not close properly.

Sydney, N. S.—Mr. R. W. Mackinnon, City Engineer of Sydney, N. S. gives the following report: "A number of chimneys which had very little mortar between the bricks came down, or had bricks shaken off the top. The rumbling noises of buildings, together with the swaying of telegraph and telephone wires, made things seem weird for a few minutes. Several leaks in the water mains were noted on Nov. 19. These mostly occurred at the joints between the lead and iron pipes."

Magdalen Islands.—A stove was reported as having been moved about a half inch along the floor.

Sable Island.—The earthquake was felt at about 4:30 p.m. and lasted for three minutes. Houses trembled. The lighthouse keeper reported that some mercury was spilt from a container. The shock was felt more at the ends of the Island. Positively no tidal wave here.

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[4] *These Transactions*, **17**, Pt. 4, 216, (1930).

Cape Race, Nfld.—The light-keeper reports that about five pounds of mercury were spilled from the revolving light.

Grand Bank, Nfld.—Mr. Howard Patten, Pharmacist, reports as follows: "I was in a general store which shook and the noise was likened unto an engine, high power, running on a loose base. When I observed people running out into the street from other buildings the thought occurred that an earthquake tremor was being experienced. The vibration was little felt outside the building. It was unnoticed by many walking along the street. No chimneys were broken."

Burin, Nfld.—Magistrate Hollett gives the following account[5]: "I was in the house when it began, about five o'clock and went out into the garden. The land trembled so violently that I could hardly stand, and the garden gate rattled as if in the wind. The sensation was similar to that felt when one stands in the stern of the ship which suddenly reverses its engines from ahead to full astern. The people had just got over the terrible fright occasioned by the earthquake when about half past seven the harbour suddenly ran out nearly dry. Immediately this was followed by the first tidal wave which came roaring in the moonlight, for it was a clear, bright and calm night. Where the land was low, like at Taylor's Bay, houses were washed inland by the first wave and carried back by the undertow. The worst damage was caused at points where the land rose rapidly, houses were washed to sea by the receding wave or thrown back by each of the succeeding waves."

At Sea.—Capt. James, S.S. Nerissa, when in N. Lat. 44°57′ W. Long 61°16½′ proceeding from St. John's to Halifax, felt the ship tremble violently at 4:35 p.m. A.S.T. This lasted for about one and a half minutes. It felt as if the main engine had suddenly been put astern. The ship fell off her course 10 degrees to port. The motion felt was similar to the effect the propeller has on the ship when it is racing in a heavy sea. However, at that time the sea was very smooth.

The estimated intensity of the shock (Rossi- Forrel Scale), at different places in Nova Scotia and Newfoundland is given in Table I.

[5] This account is taken from the *Daily News*, St. John's, Nfld., Jan. 15, 1930.

TABLE 1.

	Intensity.
Halifax	4-5
Lunenburg	4-5
Bridgewater	5
Yarmouth	4
Annapolis Royal	4-5
Windsor	5
Wolfville	5
Canso	5
Pictou	5
Dundee, N. S.	5-6
Ingonish	5-6
Sydney, N. S.	5-6
Magdalen Islands	5-6
Sable Island	5-6
Burin, Nfld.	6
Grand Bank, Nfld.	4-5

INSTRUMENTAL DATA.

Halifax:

Dalhousie University Seismograph—

North Lat. 44°38′

West Long. 63°36′

Instrument: Small Mainka Pendulum (horizontal) 139.9 Kg. Clock drive. Smoke paper records.

Period: 10.0 Secs. N. S. component
7.5 Secs. E. W. "

Magnification: 110

The record of the earthquake obtained at Halifax is of little scientific value. For some time previous to Nov. 18, 1929 the clockwork drive of the seismograph had been giving trouble and unfortunately it stopped some three hours previous to the earthquake. The earth motion, however, was sufficient to start the motor, but not soon enough to record the preliminary waves altho the later phases are recorded. Records of the "aftershocks" on Nov. 18, 19 and subsequently were obtained and the times of arrival of the phases are given in Table 2. It is found that the maximum amplitude of the P wave in the after-shock records is much greater on the E. W. component than on the N. S. component. It is also noted that the first movement is towards the west. It is to be concluded therefore that the first part of the wave to reach Halifax from the focus of the "aftershocks" was a compression.

TABLE 2.

Halifax.	Aftershocks of main earthquake.				
		h.	m.	s.	(G.M.T.)
Nov. 18	eP_e	23	03	17	
	eP_n	23	03	20	
	i_n	23	04	10	
	i	23	04	15	
	i_n	23	04	44	Felt at Burin, Nfld., and
	i_E	23	05	02	Guysboro, N. S.
	MN	23	05	26	
	M_E	23	05	29	
	F	23	13		
Nov. 19	0	(2	01	38)	
	eP	(2	02	42)	
	eS?	2	03	44	Distance = 500 km. Felt at
	i	2	04	30	Burin and Guysboro
	F	2	05	45	
Dec. 6	e	17	43	00	
Dec. 7	e	1	40	00	
Dec. 7	e	4	22	00	Felt at Mulgrave, N. S.
	eP	11	20	45	
	eS?	11	21	37	Distance = 500 km. Felt at
	i	11	22	15	Guysboro, N. S.
	F	11	24	00	

TABLE 3.

Time of Origin	Arrival of "P" Wave	Arrival of "S" Wave	Δ in degrees	Station.
h. m. s.	h. m. s.	h. m. s.		
20 31 55	20 35 18	20 37 40	12.7	Ottawa.
	20 35 11	20 37 37	12.7	Fordham.
	20 35 50	20 38 48	15.3	Buffalo.
	20 35 54	20 39 04	16.4	Georgetown.
	20 36 07	20 39 37	17.4	Charlottesville
	20 36 30	20 40 18	19.3	Ann Arbor.
	20 37 06	20 40 14	22	Milwaukee.
	20 37 06	20 41 18	22.2	Loyala.
	20 37 34	20 41 51	24.8	St. Louis.
	20 38 59	20 44 24	33.7	Saskatoon.
	20 38 09	20 42 20	40.5	New Orleans.
	20 38 48	20 43 42	34.3	Denver.
	20 40 08	20 46 37	42	Tucson.
	20 40 06	20 46 33	42.3	Hohenheim.
	20 40 49	20 47 52	47.6	Berkeley.
	20 47 (?)	20 58 (?)	78.6	St. Helena.
	20 50 (?)	—	—	Kobe, Japan.

TABLE 4.

St. Helena. Nov. 18, 1929.

		h. m. (G. M. T.)	
S. ?	e	20 54	
	e	20 57½	
L. ?	e	21 08	
	e	21 14	
	e	21 24½	
	e	21 52	Distance 8700 km.

TABLE 5.

		Barometer.	Thermometer.
Nov. 17	9 a. m.	29.99 ins.	43°F.
	9 p. m.	30.16	40
Nov. 18	9 a. m.	30.42	33
	9 p. m.	30.05	40
Nov. 19	9 a. m.	29.60	50
	9 p. m.	29.75	44

A copy of the record obtained on the seismograph operated by the Eastern Telegraph Company at St. Helena was very kindly supplied to the writer by Mr. J. C. Hagen, Supt. of the Halifax and Bermuda Cable Co., Halifax, N. S. The arrival times of different phases are given in Table 4. Owing to the great distance of St. Helena from the epicentre the phases are not well defined on this record. If 20 hr. 54 min. is taken as the time of arrival of the S Wave, the distance to the epicentre is calculated by the Klotz Tables to be 8700 km. This value accords with the tentative position of the epicentre, i. e. N. Lat. 44°30′ and W. Long. 57°15′ as given by the Dominion Obervatory, Ottawa. If 21 hr. 8 min. is taken as the time of arrival at St. Helena of the surface wave, its velocity is found to be 4.0 km. per second. This value agrees with the velocity of waves over Pacific paths as found by Neuman.[6]

Table 3 shows the arrival times of the P and S waves at various stations, and the respective distances to the epicentre. The data given are taken from various reports[7]. From the above data it should be possible to determine the average velocity for these waves at various distances from the epicentre. This will no doubt be published by others.

Cable Breaks.

The Atlantic cables off the Nova Scotia coast were severely damaged as a result of the earthquake. The cables were broken at the ends of the black lines shown in Fig. I. The numbers indicate the approximate depth of the water in fathoms. The positions are plotted from data obtained from the Western Union, Commercial and French Cable Companies. They extend from N. Lat. 39°29′ to 45°06′ and from W. Long. 52°10′ to 57°56′ and the area covered is approximately 60,000 square miles. In many cases the cables were found buried in mud and gravel. The ends appear as if the cable weie sheared

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[6] Neuman, *F. Bull. Seis. Soc. Am.*, **19**, 63.

[7] *Dominion Observatory, Ottawa, Seis. Report*, Nov. 1929.
Central Station Jesuit Seis. Ass. Special Bull., 1929.
Seis. Ber. Der. Wurtt. Erd. Hohenheim Und Ravensburg, 2 Halbjahr, 1929.

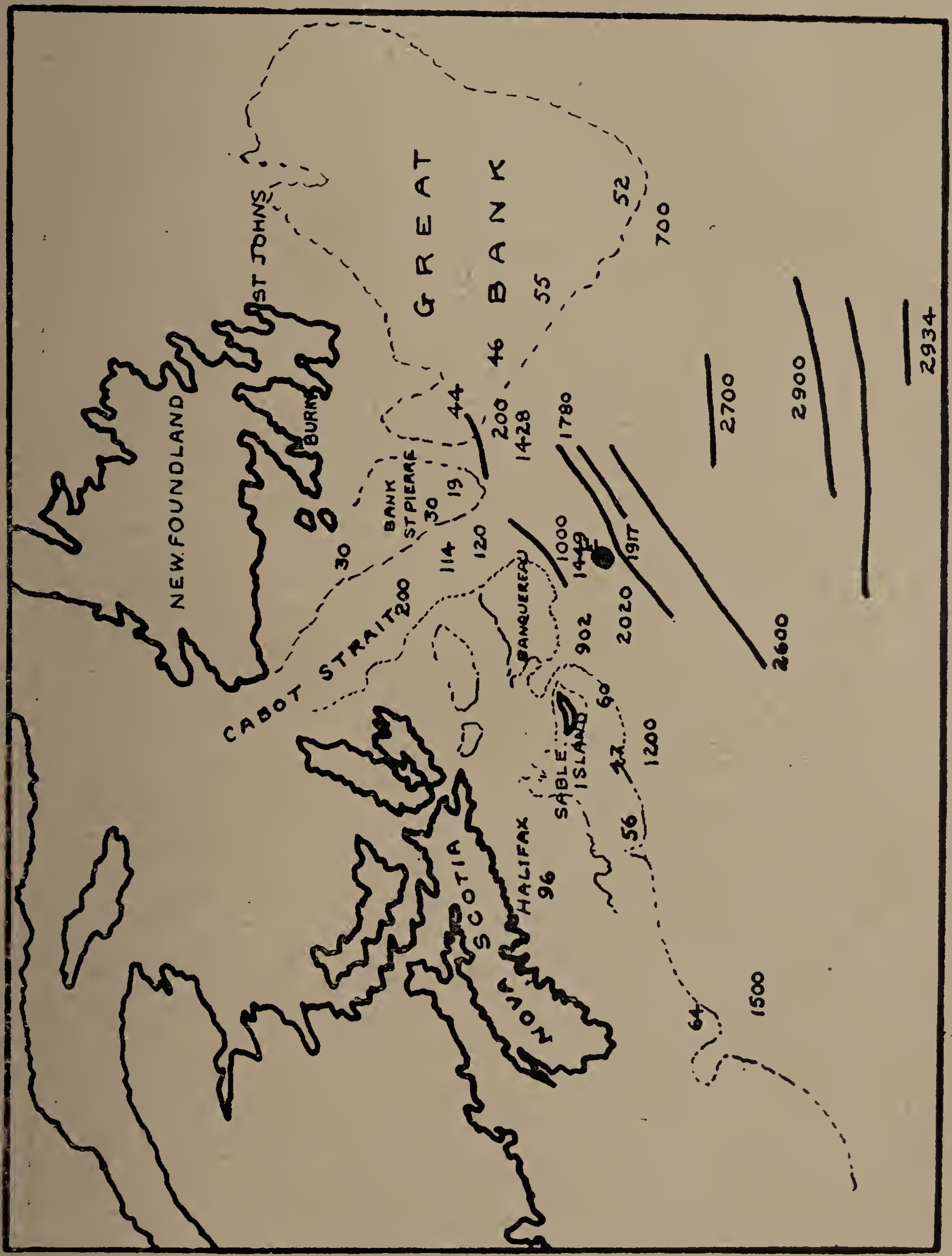
ST JOHNS
GREAT BANK
NEW.FOUNDLAND
BURIN
BANK ST PIERRE
CABOT STRAIT
NOVA SCOTIA
HALIFAX
SABLE ISLAND
BANQUEREAU
52
700
55
46
44
200
1428
1780
2700
2900
2934
19
30
30
114
120
200
1000
1449
1917
2020
902
2600
60
1200
42
56
96
64
1500

Fig. I.

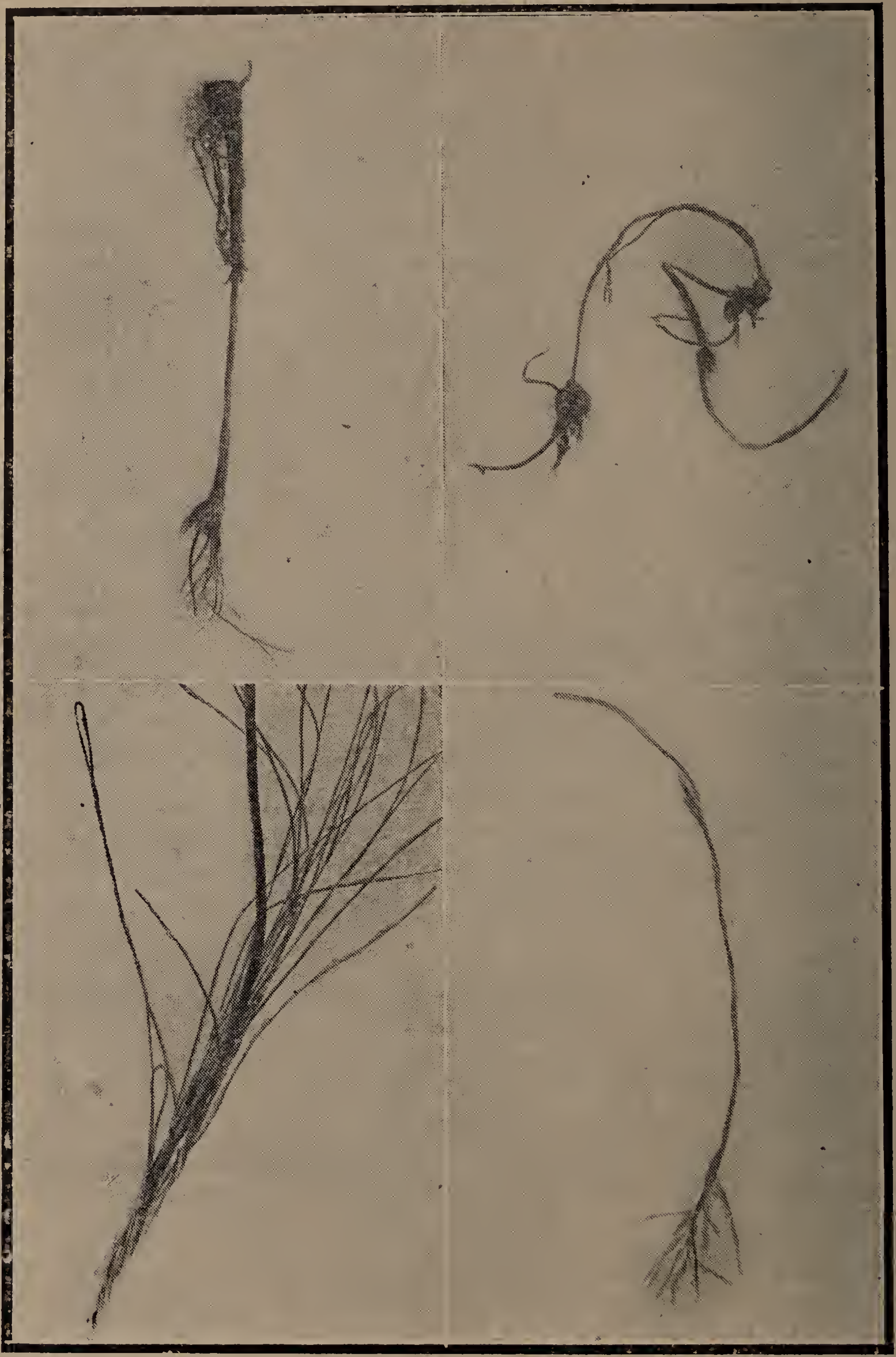

Fig. II.

off by a dull pair of heavy scissors, except at one place, where their appearance is very different. Photographs of these unusual breaks are shown in Fig. II. These ends were found by the Cable Ship Lord Kelvin[8] at N. Lat. 43°26′54″ and W. Long. 56°12′54″ in 1995 fathoms. At this location the cable was found broken up in short lengths and the core twisted around the sheath. The wires of the sheath were bent back on themselves two and three times, wound around the core and the latter twisted about the heavy galvanized steel wire sheath. To distort the cable in this manner would require the application of a very large force. I am assured that this could not be done by the grappling hook used to bring them to the surface. It seems, therefore, that this part of the ocean bed was subjected to very great vibratory and oscillatory forces, and as no other breaks show the above characteristics, it would appear that the epicentre was not far distant from the position given above, viz. N. Lat. 43°27′ and W. Long. 56°13′.

The Tidal Wave.

As is usual in the case of submarine earthquakes a water wave or Tsunami was generated by the sub-aqueous disturbance. Several studies of Tsunami have been published. Sezawa[9] in a theoretical paper shows that gravity waves are excited in deep water by seismic waves. In spite of the very small displacements of the compressional waves in the neighbourhood of the origin the waves excited in the water have relatively large amplitudes. The generated surface waves are chiefly the ordinary gravity waves, and their velocity is given by the expression $V = \sqrt{g \times h}$ where g is the acceleration due to gravity and h is the depth of the water. When the disturbance occurs at a moderate depth, however, the velocity of the surface wave is not constant, and therefore dispersion occurs.

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[8] The writer is much indebted to Capt. M. H. Bloomer, Cable ship Lord Kelvin, for drawing his attention to these cable ends and for permission to photograph and publish them.

[9] Sezawa, *Bull. Earthquake Res. Institut. Tokyo Imp. Univ.* **6**, 19; **7**, 15.

Fig. III is a copy of the tide gauge record[10] obtained at Halifax for Nov. 17, 18 and 19, 1929. It is seen that the first wave reached Halifax at 7:30 p. m. A.S.T. (almost three hours after the time of origin of the earthquake) and the tide reached its maximum height (eight feet three inches) at 11:00 p. m. A.S.T. The average speed of the first water wave was therefore approximately 165 km. per hour or 46 meters per second, assuming the distance from the epicentre to Halifax to be 500 km. Using the formula $V = \sqrt{g \times h}$, and assuming no dispersion, the average depth of the water over which the wave passed is found to be 250 fathoms, which value is not out of reason.

Tidal oscillations continued until noon Nov. 19. These are very complex in character and a harmonic analyser should be used to determine the components. A cursory examination, however, shows superimposed on the fundamental tide oscillation components which have periods of 6, 15, 29 and 150 minutes respectively. Tide gauge records of Japanese Tsunami show similar peculiarities. According to Dawson[11] secondary undulations are present at Halifax at all times, and their amplitudes may be as great as 1.5 feet. In Jan. 1899 components appeared on the tide gauge records which had periods of 6, 12, 18 and 28 minutes. In 1863 the undulations had periods of 5 to 25 minutes. At St. John, N. B., the usual period is 40 minutes. It appears, therefore, that some of the periods of the secondary undulations of Nov. 18 and 19, 1929, are characteristic of Halifax Harbour. Yamaguti[12] mentions the period of the secondary undulations of the Bay of Tokyo as 222 minutes.

The tidal oscillations were very apparent to the Captain of the Dartmouth Ferry Boat in his usual trips across Halifax Harbour. At times during the morning of Nov. 19 the currents were so variable that great difficulty was experienced in docking the ferry boat.

It is unfortunate that there are no accurate data concerning the arrival time of the wave at points on the Nova Scotia

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10. The author wishes to thank the Chief Hydrographer, Dept. of Marine and Fisheries, Ottawa, for the copy of this record so kindly supplied, and for permission to publish it.
11. Dawson, *Trans. Roy. Soc. of Can.* Seriei III, 1895, 25; 1899, 23.
12. Yamaguti, *S. Bull. Imp. Earthquake Inv. Comm.*, 9, No. 3, 95.

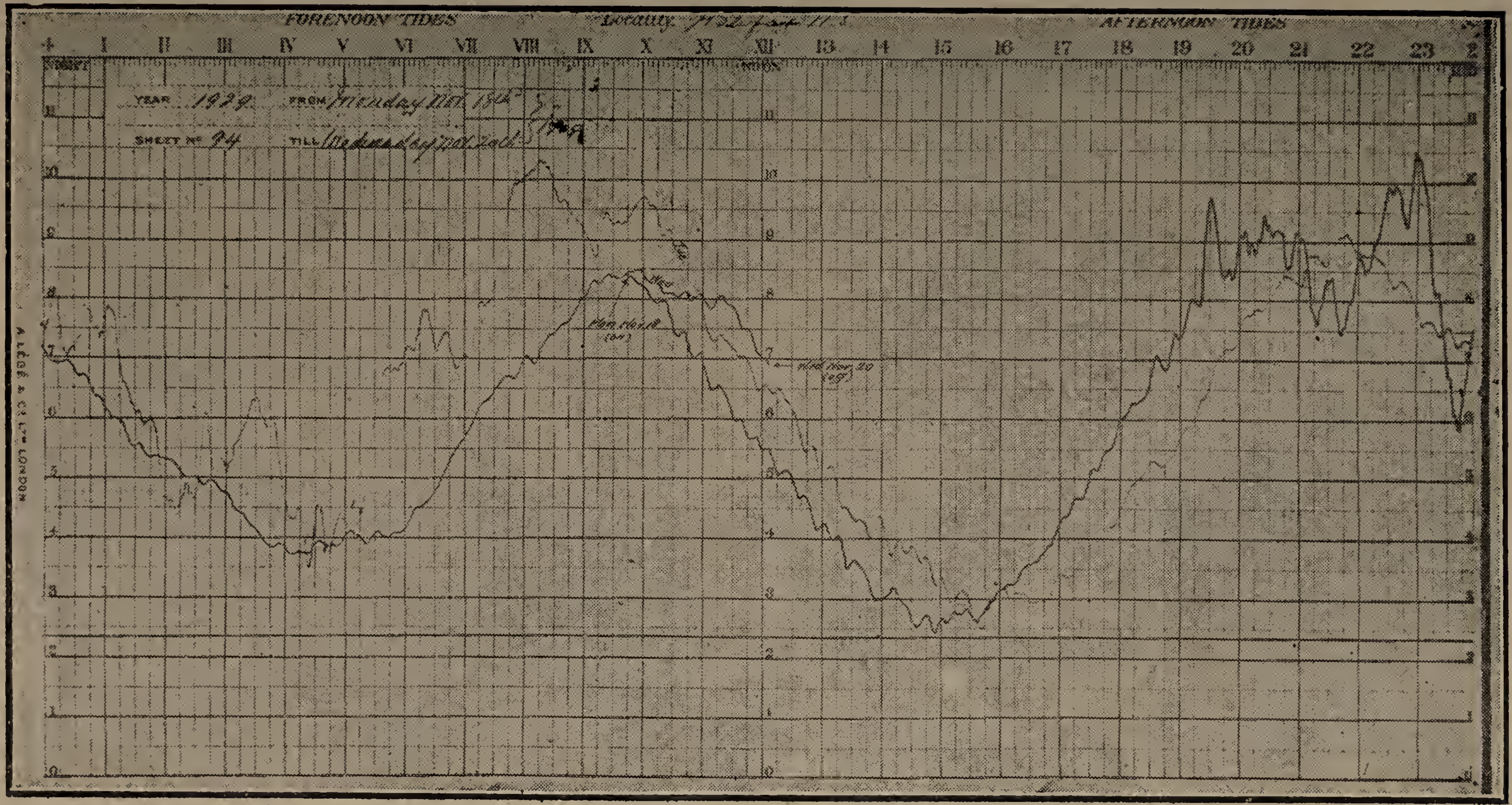
FORENOON TIDES
Locality
AFTERNOON TIDES
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
13
14
15
16
17
18
19
20
21
22
23
NOON
YEAR 1929
FROM Monday Nov 18th
SHEET No 94
TILL Wednesday Nov 20th
A. LÉGÉ & Co Ltd LONDON

Fig. III

coast, except Halifax. The Captain of the Strait of Canso Ferry reports that the wave reached its top at Mulgrave at 9:30 p. m. A.S.T. The arrival time of the first undulation at the Newfoundland coast is known approximately. Mr. Howard Patten of Grand Bank, Nfld., informs the author that the wave arrived at Burin and Lamaline at nearly the same time, viz. 7:25 p. m. A.S.T. It reached St. Lawrence (between Lamaline and Burin) at 7:15 p. m. so that the telegraph operator at St. Lawrence was able to warn Burin before the telegraph office at the former place was washed away. This would indicate that the epicentre may be further to the east than is supposed. At Burin and at St. Lawrence the water at first receded until it seemed that the harbour was going dry, and then the water returned to cause the great destruction of property and life in this vicinity. The first undulation reached Burin and Halifax at approximately the same time. If we assume the same average depth of water between the epicentre and Burin and Halifax it may be inferred that the epicentre is approximately equidistant from these two places. The location 43°30′ N. Lat. and 56°15′ W. Long. approximately satisfies the above condition. The charts however show a greater depth of water between Burin and the epicentre than between Halifax and the epicentre; moreover, there is a deep channel between the banks in line with Burin and the epicentre. There is thus evidence that the origin of the wave was south and east of the tentative epicentre previously given.

The large amplitude of the wave at St. Lawrence and Burin (the tidal bore is reported to have been 40 ft. high) can be accounted for by the narrow deep channel through which the water passed, and the possibility that a reflected wave from the Cape Race side arrived along the Burin Peninsula in phase with the direct wave. The small amplitude of the wave along the Nova Scotian coastline is probably the result of the damping action of the comparatively shallow bottom. The Sable Island and Banquereau Banks probably protected the Nova Scotian coast. It is of interest to note that no tide oscillations were observed at Sable Island. It was well protected by the surrounding sand banks.

The destructive effects at Burin and vicinity are reported by Magistrate Hollett as follows: 26 lives were lost, 32 dwellings destroyed, 27 badly damaged and others slightly damaged; 34 fishing boats, 44 power dories and 100 small dories were sunk or destroyed. In addition practically all the fishing gear of the village of this neighbourhood was washed away. Property damage is estimated at approximately $1,000,000.

Position of Epicentre.

The fact that the arcs drawn with different seismograph stations as centres are found to intersect over a considerable area and that cables were broken at different places widely separated indicates that the epicentral area was quite large or that it extended along a line. The tentative position given by the Dominion Observatory, Ottawa, is N. Lat. 44°30′ and W Long. 57°15′ and is shown at E on Fig. I. The arrival times of the water wave at Halifax and at points on the Burin peninsula. Newfoundland, indicate the epicentral area to be somewhat south and east of the above position. The location at which the peculiar cable ends, were found, viz., N. Lat. 43°27′ and W. Long. 56°13′ supports this conclusion. A more careful examination of the "seismograph arcs" will no doubt throw more light on this point.*

In conclusion the writer wishes to thank the many persons who supplied much of the information discussed in this paper.

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*Since this was written, F. A. Hodgson and W. W. Doxsee in a paper presented to the Eastern Section of the Seismological Society of America, state that seismograph data seem to point to a location near N. Lat. 44°.5′ and W. Long. 55°15′.

THE EDEMA OF PARA-PHENYLENEDIAMINE.—By O. S. GIBBS, M.B., CH.B., Department of Pharmacology, Dalhousie University, Halifax, N. S.

(Presented 13 January 1930).

ABSTRACT.

Continuous small injections (0.02 cc. per 2 sec. of 0.4% paraphenylenediamine), when introduced into arteries without interfering with the blood flow, caused marked edema of the part supplied. Trypan blue added to the injecting fluid intensified this effect by coloration. It is concluded that para-phenylenediamine is poisonous to all vessels if acting in sufficient concentration over sufficient time.

Some years ago I published a paper[1] concerning edema of para-phenylenediamine in which, on the basis of certain results unlike those of previous authors who claimed a specific action localized in the head and neck tissues, I concluded that the edema produced was in reality to be considered as evidence of a generalized poisoning. This view was contradicted by Hanzlik[2], Tainter[3], and others who again postulated gross specificity of the head and neck area.

Investigation of this question has brought to light, however, evidence supporting my view that the poisoning of para-phenylenediamine is really to be considered as a generalized condition with marked lesions usually in the head and neck, rather than a specific action confined to the head and neck. All authors agree that at the site of injection of para-phenylenediamine marked edema occurs showing that this substance is edema-forming providing that there is present a sufficient concentration of the drug, or perhaps a lesser concentration acting over a longer period.

EXPERIMENTAL.

Experiments were conducted in which, by means of a fine needle inserted into an artery, para-phenylenediamine was injected into the blood stream of a given area without inter-

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1. Gibbs, *J. Pharmacol.*, **20,** 221 (1922).
2. Hanzlik, *J. Ind. Hyg.*, **4,** 386 (1923).
3. Tainter, Hanzlik, *J. Pharmacol.*, **24,** 179 (1924).

fering with the normal blood supply. Approximately 0.1 to 0.2 grams of para-phenylenediamine per kilo were injected, using cats as subjects. The para-phenylenediamine was dissolved in about 25 cc. of saline and was injected at the rate of 0.02 cc. per 2 sec. In all cases a marked edema occurred in the area of arterial distribution. These experiments were repeated with the addition of 0.2 gram trypan blue to the injecting fluid. In all cases the injected area showed a deep staining of the trypan blue. Similar experiments with trypan blue alone as control did not give staining. It is clear from these experiments that para-phenylenediamine is able to produce edema in any area if conditions be suitable. A study of these conditions is being made and will be reported in a further publication.

The explanation of the localization of the effects of para-phenylenediamine in the head and neck area which is commonly seen is as yet not clear.

A SEPARATORY FUNNEL FOR WASHING HEAVY, VOLATILE LIQUIDS.—

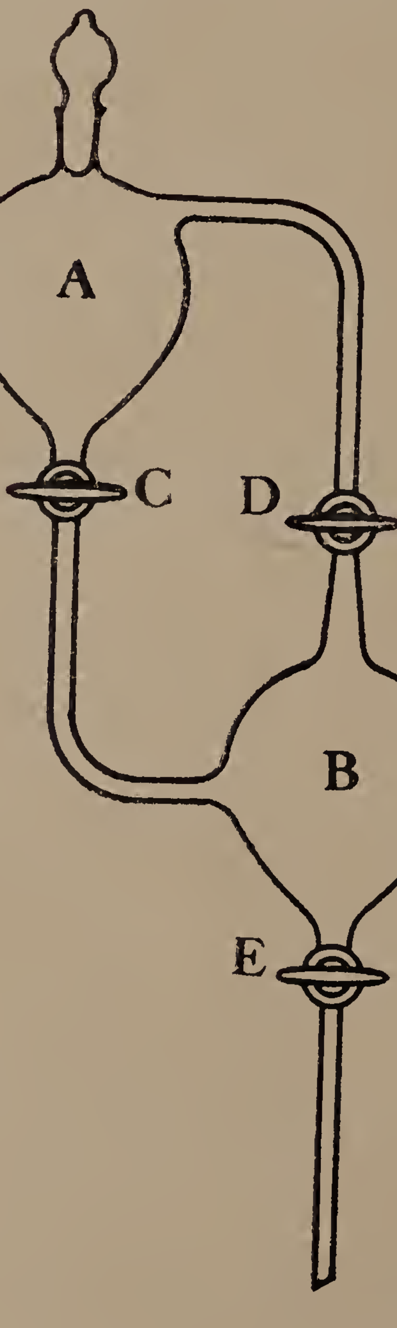
By HAROLD S. KING, PH.D., Department of Chemistry, Dalhousie University, Halifax, N. S.

(Presented 14 April 1930).

ABSTRACT.

Two separatory funnels are sealed together in such a way that a heavy liquid in the first can be separated from a supernatant liquid and delivered to the second funnel without contact with the outside atmosphere. After removal of the supernatant liquid, the heavy liquid can be returned to the first funnel for rewashing.

The technic employed in washing a liquid depends on the relative densities of the two fluids. When the wash liquor is the heavier, as in the case of washing ether with water, the procedure is simple. The mixture is shaken in a separatory funnel, allowed to separate and the heavier aqueous layer drawn off through the stopcock. A fresh portion of water is added and the process repeated, the liquid washed remaining in the separatory funnel throughout the process.



The case is different when the liquid to be washed is heavier than the wash liquor. Here the heavy liquid is removed from the separatory funnel at the end of each washing. If the heavy liquid is volatile, there will be loss by evaporation, especially when several extractions are necessary.

To avoid this loss the piece of apparatus illustrated in the accompanying figure was designed.

It is made by joining together two ordinary separatory funnels. The two liquids are shaken together in bulb A. The apparatus being held upright, stopcock D is opened, then the heavier layer is delivered to bulb B by opening stopcock C. After closing the stopcocks, the lighter wash liquor is poured out of A and a fresh portion added. The liquid in B is returned to A by inverting the apparatus and opening the stopcocks C and D. All is then ready for a repetition of the process.

The apparatus has been very useful, especially in the washing of alkyl iodides, its use enabling us to improve the yields of these volatile substances. In spite of its seeming fragility, it is not easily broken, no accidents having occurred during frequent use. If desired, however, it may be wired to a board in which two holes have been cut for the insertion of the bulbs.

In cases where an inert atmosphere is desirable, the stopper to bulb A is replaced by a two-holed stopper bearing tubes through one of which the gas can be admitted and through the other the liquid introduced or removed.

NOTES ON THE PREPARATION OF ALKYL IODIDES.—By HAROLD S. KING, PH.D., Department of Chemistry, Dalhousie University, Halifax, N. S.

(Presented 14 April 1930).

ABSTRACT.

In the preparation of alkyl iodides by a modification of Adams' method the use of anhydrous alcohol is not necessary. The addition of 10 per cent. by weight of water to methyl alcohol did not reduce the yield of methyl iodide. The start of the reaction is smoother if part of the alcohol is put in the iodine container and allowed to run in on the phosphorus and the rest of the alcohol heated to 70-75°C.

Since we reported some years ago on "A Modification of the Adams' Method of Preparing Alkyl Iodides"[1], certain changes have been adopted. The notes here given are merely addenda to the above article, to which the reader is referred for details of the procedure and apparatus employed.

It was at first thought necessary to use absolute alcohol in these preparations. It has now been found that the presence of water is not deleterious. In the preparation of methyl iodide, the methyl alcohol was diluted with 10 per cent. of its weight of water. The yield was identical with that of a check experiment in which absolute methyl alcohol was used. The presence of water does not cause an evolution of hydrogen iodide. A tube from the top of the condenser dipped under water. After the experiment this water was found to be neutral to litmus. The methyl iodide, distilled from the reaction flask, was collected under a slush of ice and water. This also was neutral.

In the original procedure the alcohol was put in the reaction flask together with red and yellow phosphorus and the mixture heated to 100°C so that the liquid in refluxing dissolved the iodine on the way back to the reaction flask. At the beginning of the reaction methyl alcohol is the refluxing liquid; after some time methyl iodide takes its place. The temperature then must be lowered, partly because methyl iodide is more volatile and partly because iodine is more soluble in it than in the alcohol. It would be an advantage if the refluxing began with methyl iodide so that no change in the temperature would be necessary. To accomplish this the iodine crystals are covered with part of the methyl alcohol and the alcoholic solution of iodine is run slowly into the reaction flask, which holds the phosphorus and the rest of the alcohol, and heated to between 70° and 75°C. By the time that all the solution has reacted, sufficient methyl iodide has been formed to start the refluxing. This modification is of even greater value in making the higher alkyl iodides, expediting their preparation to a considerable extent.

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[1] King, *These Transactions*, **16**, Pt. 2, 87-91 (1924).

A NOTE ON THE BIOLOGICAL ASSAY OF TINCTURE DIGITALIS.—By G. A. GRANT, M.Sc. and S. G. ALEXANDER, Maritime College of Pharmacy, Dalhousie University, Halifax, N. S.

(Presented 17 March 1930).

ABSTRACT.

The strength of several samples of Tr. Digitalis obtained at random on the local drug market is determined by the method of biological assay outlined at the Geneva Conference and now adopted as in accordance with the requirements of the Canadian Government. The samples are compared in strength with the present U.S.P.X. standard and with the International standard powder of Digitalis. The results obtained indicate that for the tinctures examined the maximum deviation from the U. S. P. **X**. standard is much less than that previously found, and also that the strength of the International powder is considerably above that of the present U. S. P. X. standard.

In the case of certain potent pharmaceutical preparations the usual chemical method of assay is impossible due to the complexity of the active principles and the difficulty involved in their separation. It is customary in such cases to assay the preparations biologically by their effect on experimental animals. Tincture of Digitalis belongs to this group of biologically standardized preparations.

Our attention was directed to this investigation for several reasons. Rusby[1] found that the reports of the biological assay of another drug, ergot, gave extremely discordant results; assays of the same lot of ergot referred to different analysts and to the same analysts at different times yielded results varying from 90.9 to 167 percent. Equally discordant results were obtained or a sample of the fluid extract, the same sample was reported anywhere from 128-250 percent. These findings indicate the present U. S.P X. biological assay for ergot to be of questionable value. In regard to Digitalis preparations Wokes[2] found amongst 80 samples of tincture that a variation of activity of nearly 400 percent occurred—25 samples differing by more than the permitted 25 percent deviation from the International standard powder. Rowe[3] reported a series of results for various tinctures, the deviation found here being about 130 percent; while Ward[4] investigating a series of tinctures purchased on the open Canadian market found a variation in potency of 120 percent. Samples were found as low as 30 percent and as high as 150 percent if the U. S. P. standard, a mean lethal dose of 0.006 cc. per gram weight of frog be taken as 100 percent. Since the investigations of Ward the International standard powder of Digitalis has been adopted as its standard by the Canadian Government.

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[1] Rusby, *J. Am. Pharm. Assoc.*, **18**, 1125 (1928).

[2] Wokes, *Quart. J. Pharm. and Pharmacol.*, **2**, 48, (1929).

EXPERIMENTS.

The following results represent the potency found upon the assay of a few samples of Tincture of Digitalis obtained at random on the local open market. They have been assayed in accordance with the U. S. P. X. requirements and the results compared with the International standard powder, the latter supplied through the courtesy of the Department of Health at Ottawa. The samples assayed were obtained in their original containers. Healthy male frogs, procured from American Biological supply houses, were used for the assay. The four hour frog method of the Geneva Conference was used in preference to the one hour method of the U. S. P. X. The required dose of the diluted tincture was injected into the breast lymph sac of the frog through the floor of the mouth by means of a Luer Tuberculin syringe graduated in hundredths of a cubic centimeter. At the end of the four hours the frog was pithed, if necessary, and the heart examined; systolic stoppage of the ventricle being indicative of a positive result provided no unabsorbed tincture was found present in the lymph. A first approximation of the mean lethal dose was obtained from a series of several frogs injected with doses varying by 20 percent per gram weight of frog. The final tests consisted of the injection of frogs with doses differing by 10 percent per gram weight of frog from the approximate mean lethal dose found above. The determination is completed when of two

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3. Rowe, *J. Am. Pharm. Assoc.*, **18,** 1138 (1928).
4. Ward, *Can. Med. Assoc. J.*, **16,** 409-12 (1926).

doses the higher kills a majority of the frogs injected, the lower, a smaller number.

TABLE 1.

	cc. Tincture per gm. frog.	Frogs injected.	Positive results	Mean lethal dose cc. per gm. frog.
1. TINCTURE A. Age of tincture 3 months	.0080	1	1	.0072
	.0075	3	3	
	.0070	3	2	
	.0065	3	0	
	.0060	1	0	
2. TINCTURE B. Dated: To be used before Dec. 16, 1930.	.0065	5	5	.0052
	.0055	5	5	
	.0050	5	4	
	.0045	5	3	
3. TINCTURE C. Dated: Made June 4, 1929.	.0075	3	3	.0070
	.0070	3	2	
	.0065	3	2	
	.0060	3	1	
	.0055	3	0	
4. TINCTURE D. No date	.0072	6	4	.0065
	.0065	6	2	
	.0058	6	3	
	.0050	2	0	
5. TINCTURE INTERNATIONAL POWDER: Extracted by U. S. P. X. Process. Tested immediately.	.0055	1	1	.0038
	.0050	4	4	
	.0045	4	4	
	.0040	4	4	
	.0035	6	3	
	.0025	6	2	
6. TINCTURE INTERNATIONAL POWDER: Extracted by the method of the International Conference.	.0048	1	1	.0032
	.0043	3	3	
	.0038	3	3	
	.0035	3	3	
	.0030	3	1	

CONCLUSIONS.

Considering the present U. S. P. X. definition of Tincture of Digitalis as one which has a mean lethal dose of .006 c. c. per gram weight of frog, the following tables of comparison are obtained.

TABLE 2.

TINCTURE	I	Percent	II
A	83		48
B	115		67
C	86		50
D	92		54
International Powder	171		100

I. U. S. P. X. Requirements: Mean Lethal Dose 0.006 cc. per gm. frog –100 percent activity.

II. Requirements: 1 cc. Tincture =1 cc. International tincture (within 25 per cent).

The maximum deviation of Tinctures examined was 32 percent except for the International powder which gave a figure about 70 percent over U. S. P. X. activity when measured by method I while in method II the maximum deviation was 52 percent.

The authors regret being unable to procure in time for this report a sample of the U. S. P. standard ouabain to complete the comparison with the International standard. The results of Edmunds, Lovell and Branden[5] however, with an ouabain standard for comparison indicate the International standard powder used in their assays to be about 30 percent stronger than the present U. S. P. X. standard. The results here obtained indicate that for the tinctures examined the maximum deviation from the U. S. P. X. standard is much less than that previously found; they also seem to indicate that the International standard sample used in this investigation is apparently considerably stronger than the present U. S. P. strength. It would seem advisable that in the near future all tinctures be standardized to conform to the Canadian Government requirements, which are those originated and adopted by the International Conference. We take this opportunity of thanking Dean Burbidge for his interest in making this investigation possible.

[5] Edmunds, Lovell and Branden, *J. Am. Pharm. Assoc.*, **18**, 778 (1928).

THE PREPARATION OF ABSOLUTE ETHYL ALCOHOL.—By E GORDON YOUNG, PH.D., Department of Biochemistry, Dalhousie University, Halifax, N. S.

(Presented 13 January 1930).

ABSTRACT.

A comparative study has been made with reference to percentage yield and cost per litre of product of three methods of preparing absolute alcohol for ordinary chemical procedures and for histological work. These comprise: (1) the carbide method, (2) fractional distillation with benzene, (3) the lime method. It is concluded

(1) That the carbide method produces the best yield (95%) at a cost slightly higher than the lime method but of a product from which it is difficult to remove traces of impurities of objectionable odour, if ordinary carbide is used. This is the most rapid procedure.

(2) That the method of benzene distillation is impracticable on a laboratory scale.

(3) That the lime method is the cheapest with a yield of about 80%. It is recommended in the proportion of 300 gms. of fresh lime to 1 litre of 95% alcohol, refluxed for about four hours and distilled.

Methods for the preparation of absolute ethyl alcohol are very numerous. (MacArdle,[1]). Few of them, however, are well suited to the production of large quantities on a laboratory scale. For economic reasons it became necessary to prepare absolute alcohol of a grade of 99.6% or slightly better in half gallon quantities, frequently, at as low a cost as possible. This product was to serve for the dehydration of histological sections, both plant and animal, and also for a variety of organic chemical work not requiring any high degree of purity as regards water content. In the course of some three or four years experience records have accumulated in the comparison of costs and optimal conditions for several methods. For the reason that our problem has undoubtedly arisen in many laboratories, yet the literature contains so few articles bearing on the economic production of absolute alcohol in the laboratory as contrasted with its commercial preparation, a brief report of our results has been deemed advisable.

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1. MacArdle, *Solvents in Synthetic Organic Chemistry*, D. Van Nostrand Co., New York, pp. 51-73, (1925).

The methods selected for trial were (1) the calcium carbide process, (2) fractional distillation with benzene, (3) the unslaked lime process. Our results have shown that although much the best yields are obtained with carbide the lime procedure is the most economical under the conditions developed. The benzene method, despite its general commercial use, is not applicable in the laboratory, unless possibly very large quantities are required. We have had no experience with the glycerol method.

In computing costs no account has been taken of the time of the attendant, nor of the coal gas consumed. A laboratory assistant usually carried out the operations in spare time. The cost of the original ethyl alcohol, 65 o. p., (95.0%) laid down in Halifax, N. S., was between $2.45 and $2.77 per Imperial gallon.

EXPERIMENTAL.

The Carbide Method.—There are few references in the literature to the use of calcium carbide for dehydrating alcohol. It was first suggested by Yvon[2] in the proportion of 25 gms. of carbide to 100 gms. alcohol, 90-95%, followed by a second distillation in the presence of anhydrous copper sulphate. The method was applied to the preparation of absolute methyl alcohol by Cook and Haines[3]. Lyons and Smith[4] revived the method in 1925 using 17.5 gms. of carbide of 20 mesh size and 81% purity. They refluxed the mixture for 30 minutes and recommended the addition of anhydrous $CuSO_4$ to remove acetylene as did Yvon. Their yield was 98.7% and the grade of dehydration 99.86% by volume.

We have followed the general procedure of Lyons and Smith but have found it necessary to use a proportion of 25 gms. of coarsely powdered commercial carbide to 100 gms. of 95% alcohol. This mixture was refluxed for two hours; then 1 gm. anhydrous $CuSO_4$ was added per 100 gms. alcohol and refluxing continued for one hour. The product was then distilled and assayed 99.7% by volume with a specific gravity of 0.796. This material however frequently possessed a marked odour despite the copper treatment. A second treatment with anhydrous $CuSO_4$ in the proportion of 1-2 gms. per 100 gms. followed by distillation usually removed the odour but decreased the yield to 95% of theoretical. The cost per litre of absolute over the preparation of an Imperial gallon became $1.34; in the best run it was $0.89. This is calculated on the basis of 1 lb. carbide at $0.20 and 1 lb. $CuSO_4$ $1.15.

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[2] Yvon, *Compt. rend.*, **125**, 1181, (1897).
[3] Cook and Haines, *Proc. Iowa Acad. Sci.*, **9**, 86, (1901).
[4] Lyons and Smith, *Science*, **62**, 224 (1925).

The Benzene Method.—The procedure of Young[5] was followed in detail using a fractionating column of 22 bulbs. The results of one experiment will illustrate the difficulty of applying this method to small scale operations. 2000 c.c. alcohol and 1500 c.c. benzene were mixed and fractionated into the usual four fractions separating as follows:

(1) ternary mixture, 64.8-67.5°—2000 c.c.
(2) binary mixture, 67.5-73.0°—375 c.c.
(3) binary mixture, 73.0-78.3°—800 c.c.
(4) absolute alcohol, 78.3°—300 c.c.

Without doubt too much benzene was used initially. The time required for efficient separation coupled with the small yield obtained make this method impossible on a laboratory scale. The details of recovery of the benzene and refractionation of the various mixtures are omitted.

The Lime Method.—The procedure in vogue at different laboratories varies greatly in carrying out dehydration of alcohol with unslaked lime. In 1907 Kailan[6] published a paper in which two variables, ratio of lime to alcohol and time of contact, were investigated. His conclusions as regards the first were that no difference in the rate of dehydration was apparent between 250 and 410 gms. of lime per litre of alcohol and that above 400 gms. the rate increased rapidly. The yield of alcohol was however decreased proportionally. Adopting 550 gms. per litre as a good proportion Kailan found that three and a half hours' refluxing produced a grade of 99.5% while six hours increased the dehydration to 99.9%. The same result could be attained by standing at room temperature for twenty-four days. Ln 1910 Warren[7] published the description of a copper still for making absolute alcohol by the lime method. He claimed that 99.87% was the best possible grade obtainable by this process. He refluxed for six hours with a large excess of lime but does not state the exact amount. Twenty-four hours' standing in contact with lime at room temperature saved one hour in refluxing. His yield was approximately 70% of theoretical. Wightman, Wiesel and Jones,[8] prepared a sample, 99.964%, sp. gr. 0.785067, for conductivity purposes by boiling with lime for several days. Dannar and Hildebrand[9] in preparing absolute alcohol for the same purpose used a proportion of 600-700 gms. per litre of 95% and refluxed eight hours, besides purifying it in other ways. Finally Noyes[10] in 1923 published the results of preparing large quantities of absolute for special work in his laboratories using a proportion of 250 gms. of lime per litre of 95% grade and refluxed on a steam cone overnight; then distilled to yield a grade of 99.6-99.7%. There was a loss of 7-8% despite a prolonged heating of the lime residue. A fresh treatment of this grade in the proportion of 40 gms. powdered lime per litre produced 99.9% absolute. Lassar-Cohn[11] favors the old method used by Squibb[12] of prolonged treatment with lime in the cold, requiring eight to fourteen days. There is thus in the literature divided opinion as to time of contact (from 3½ hours to 14 days), as to proportion of lime (from 250 gms. to 700 gms. per litre of 95%), and as to the temperature employed.

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[5] Young, *J. Chem. Soc.*, **81**, 707, (1902).
[6] Kailan, *Monatsh.* **28**, 927, (1907).

Our practice has been to start the individual preparations listed below with three litres of 95.0% by volume in a 5 litre pyrex flask on a sand bath using a 24 inch condenser. In refluxing we have found the use of a trap containing a few cubic centimeters of alcohol increases our yield. In collecting the absolute during distillation from the lime residue the product is protected from the air by a calcium chloride tube in the receiver. This we have found a necessary precaution because of the absorption of water from the air during the course of the distillation. Winkler[13] claims the absorption of 0.1% in 15 minutes; Crismer[14] 0.2% in 25 minutes, and 0.7% in 90 minutes. We have found our preparations, at first negative to the $KMnO_4$ and CaC_2 tests, passing over the absolute line of 99.5% and becoming positive to these tests in a few hours. The specific gravities were determined by accurate spindles at 15°C. and converted to percentage by volume figures from standard tables.

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[7] Warren, *J. Am. Chem. Soc.*, **32**, 698, (1910).

[8] Wightman, Wiesel, and Jones, *J. Am. Chem. Soc.*, **36**, 2243, (1914).

[9] Dannar and Hildebrand, *J. Am. Chem. Soc.*, **44**, 2826. (1922).

[10] Noyes, *J. Am. Chem. Soc.*, **45**, 859 (1923).

[11] Lassar-Cohn, *Organic Laboratory Methods*, Trans. from the 5th. German Ed., by R. E. Oesper, Williams & Wilkins, Baltimore pp. 394-395, (1928).

[12] Squibb, *Z. anal. Chem.*, **26**, 94, (1887).

Our first few runs demonstrated the importance of the use of *fresh* unslaked lime in obtaining a good yield of absolute quality. The procedure in Table 1 was to allow the lime to remain in contact with the alcohol for 24 hours at room temperature, then to reflux three hours and distil.

TABLE 1.

Alcohol c.c.	Lime gms.	Yield c.c.	Concentration %	$KMnO_4$ Test.
1000	450	600	99.5	+
1000	350	730	99.2	+
1000	300 (fresh)	700	99.7	—
1000	250 (fresh)	730	99.2	+

The theoretical amount of lime required to dehydrate completely one litre of 95% alcohol is 155 gms. (CaO).

From several experiments done with and without the procedure of preliminary standing using the same quantity of lime it was proven that early contact in the cold could be neglected as it did not alter either yield or the time of refluxing materially. Furthermore an accumulation of finely divided lime on the bottom of the flask increased the danger of cracking the flask on subsequent heating. The yield of absolute alcohol depends upon the ratio of lime to alcohol, and upon the time of heating of the lime residue. The former is apparent from the following table in which all runs were simply refluxed for 2½ hours, then distilled.

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[13] Winkler, *Ber.*, **38**, 3612, (1905).

[14] Crismer, *Bull. Soc. Chim. Belg.*, **18**, 18, (1904).

TABLE 2.

Alcohol c.c.	Lime gms.	Yield c.c.	Concentration %
1000	200	785	98.3
1000	300	730	98.8
1000	400	670	99.1
1000	500	580	99.5

The concentration of alcohol is thus shown to be directly proportional to the amount of lime used as one would expect. The yield is however inversely proportional, if the same care is taken in baking the lime residue until practically no further distillate is obtainable. This is an important factor in yield and consequently in cost. Yields may vary tremendously if the latter part of the distillation is not prolonged. This is shown in Table 3. We have always found under our conditions of heating that the last few cubic centimeters of distillate are as good, if not better in quality, than the whole. Furthermore an adequate amount of baking causing the lime mass to dry and crack forms a residue which can be shaken into small lumps and removed from the flask without difficulty.

TABLE 3.

Alcohol c.c.	Lime gms.	Yield c.c.	Concentration %
1000	300	670	99.7
1000	300	570	99.7
1000	250	580	98.8
1000	300	730	99.2
1000	300	600	99.4

The factor of time of refluxing was next considered in relation to the practicability of the preparations being complete in the course of a day. Table 4 illustrates several distillations with this end in view.

TABLE 4.

Alcohol c.c.	Lime gms.	Yield c.c.	Time of Refluxing hrs.	Concentration %
1000	300	730	2.5	98.8
1000	300	725	4	99.7
1000	300	720	5	99.9
1000	300	740	7	99.9
1000	200	760	6	99.2

It would be supposed, *a priori*, that if the lime were in a finely powdered state rather than in coarse lumps the rate of dehydration would be considerably accelerated. A single comparative experiment was done to test this. Two lots of alcohol were treated with 300 gms. of lime each, one finely powdered and the other coarse lump. They were allowed to stand at room temperature for 24 hours, refluxed for 2½ hours, then distilled. The yield from the finely powdered lime was 570 c.c. per litre of 98.8% grade, from the lump, 700 c.c. per litre of 99.4%. There is thus a disadvantage in using powdered lime, as neither the yield nor the grade is quite as good. Probably in the process of powdering the lime a certain amount of moisture is absorbed which decreases its efficiency. Furthermore the manual labor involved is very tedious. Finally there is increased danger of caking during heating with the possibility of cracking a glass container with resultant fire. The lumps break up quickly after boiling sets in so that over a period of several hours any advantage that the powder may have in theory is lost.

Cost of Production. The yield of alcohol under optimal conditions outlined above is about 78%. The low cost of alcohol and of lime however compensates for the low yield. Allowing lime at our purchase price of $1.00 for 50 lbs., and alcohol at $2.50 per Imperial gallon, the cost per litre of absolute becomes $0.89. This is very favourable as compared with $1.34 per litre as prepared by the carbide method and equal to the best experiment of this method. Furthermore the yield of absolute by the lime procedure could probably be bettered with care and practice.

It is evident from the preceding tables that different amounts of lime may be used to prepare the absolute grade since the time required for refluxing varies inversely as the amount of lime used. This is mentioned because our experiments were used to demonstrate the most economical method of producing about two litres at a distillation. If larger amounts were required it would be more economical probably to decrease the amount of lime to 200-250 gms. and increase the length of refluxing to 8-10 hours, as recommended by Noyes[10] since the preparation could not be finished in a working day.

AN ATTEMPT TO DEMONSTRATE THE EXISTENCE OF SHORT RANGE ALPHA PARTICLES FROM RADIUM C.—By G. H. HENDERSON, PH.D., and J. L. NICKERSON, M. SC., Department of Physics, Dalhousie University, Halifax, N. S.

(Presented 13 November 1929).

ABSTRACT.

An attempt has been made to detect short range particles from RaC by the Wilson chamber method but no group of particles of definite range could be detected above the general background.

It has long been known that radium C can disintegrate in two ways. The great majority break up emitting a β particle with a half value period of 19.7 minutes giving rise to radium C′, a substance of extremely short life emitting the well known group of α particles of range about 7 cms. About 3 or 4 in 10000 RaC atoms however break up with emission of an α particle giving radium C″ followed by a β ray change leading again to RaD.

$$\begin{tikzcd}
 & \text{T=45 d.} & & & \\
 & \text{0.04\%} & \text{RaC}'' \arrow[dr, "\beta"] & \text{T=1.32 min.} & \\
\text{RaB} \arrow[r] & \text{RaC} \arrow[ur, "\alpha"] \arrow[dr, "\beta"] & & \text{RaD} & \\
 & \text{99.96\%} & \text{RaC}' \arrow[ur, "\alpha"] & \text{T=}10^{-7}\text{ sec.} & \\
 & \text{T=19.7 min.} & & &
\end{tikzcd}$$

Radium C″ was isolated by Hahn and Meitner[1] by recoil and was shown to decay with a period of 1.32 minutes giving out β rays. The emission of α rays from RaC has never been demonstrated experimentally. From the branching ratio it can be surmised that the period of these RaC atoms is about 45 days and from the Geiger-Nuttall relationship their α particle range should be about 3.6 cms.

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[1] Hahn and Meitner, *Phys. Zeit.*, **10**, 697, (1909). Fajans, *ibid.*, **12**, 369, 378, (1911). **13**, 699, (1912). Albrecht, *Wien Ber.*, **128**, 925, (1929).

To demonstrate the existence of these 3.6 cm. particles, if they exist, is difficult, as they are swamped by the overwhelming number of 7 cm. particles from RaC′. The most promising method seemed to be that of the Wilson chamber. Preliminary calculations showed a reasonable possibility of solving the problem and experiments were made. The attempt however was negative as will be seen.

METHOD.

The method consisted in photographing large numbers of a particles from a source of the active deposit of radium (which had decayed long enough to eliminate all RaA), measuring up the short tracks and seeing if there existed a group of these particles of definite range. The chief source of error would be RaC′ particles shortened by passing through the edges of the slit system. Accordingly great care was taken with the slit system and also with the purity of the source to reduce the errors to a minimum.

The Wilson chamber was 6 cm. in diameter. The piston was moved by a spring and cam. To avoid contamination the source was separated from the chamber by a mica window of 1.1 cm. air equivalent. The source was a platinum button 1.1 mm. in diameter. After exposure to the emanation it was washed with alcohol and heated in vacuo.

The slits were made of silver foil of 12 cm. stopping power. The first, 0.7 mm. in diameter, was placed directly in front of the mica window. Being smaller than the source it eliminated any effect due to the edge or the side of the source. The second was a slit 1.4 cm. long and 0.5 mm. in width placed on a circular arc 1.2 cm. distant from the mica. A screen on the piston uncovered the slit only during the last millimeter of the stroke.

Pictures were taken on standard cinematographic film, an arc being the illuminant. Only short tracks with well defined ends were counted. A number of tracks with poorly defined ends, probably due to particles coming late in the expansion, were excluded.

RESULTS.

About 6400 tracks were photographed, which was sufficient to show that the effect looked for could not be found. Short tracks were present in much larger numbers than were to be expected. The number of tracks between 3.3 and 6 cm. in length was about 2.1% of the total against a calculated value of less than 0.3% due to edge effects at the slits. The tracks were fairly uniformly distributed in length with no more variations than would be expected from probability variations in the small numbers involved. There was no sign of any definite group. These experiments cannot be said to disprove the existence of the RaC α particles, for the background found was great enough to swamp completely the sought-for group from RaC.

The reason for this excess number of short range tracks is unknown, but the result is in keeping with the general impression gained in counting scintillations in a magnetic spectrum of the rays. It is possible that there may exist a continuous distribution of slower α particles from a radioactive source in addition to the homogeneous group. The proof or disproof of this point would require considerable further experimentation.

NOTES ON THE SPECIFIC GRAVITIES OF LIQUID AND SOLID SULPHURIC ACID

—By D. McINTOSH, D.Sc., Department of Chemistry, Dalhousie University, Halifax, N. S.

(Presented 13 January 1930).

ABSTRACT.

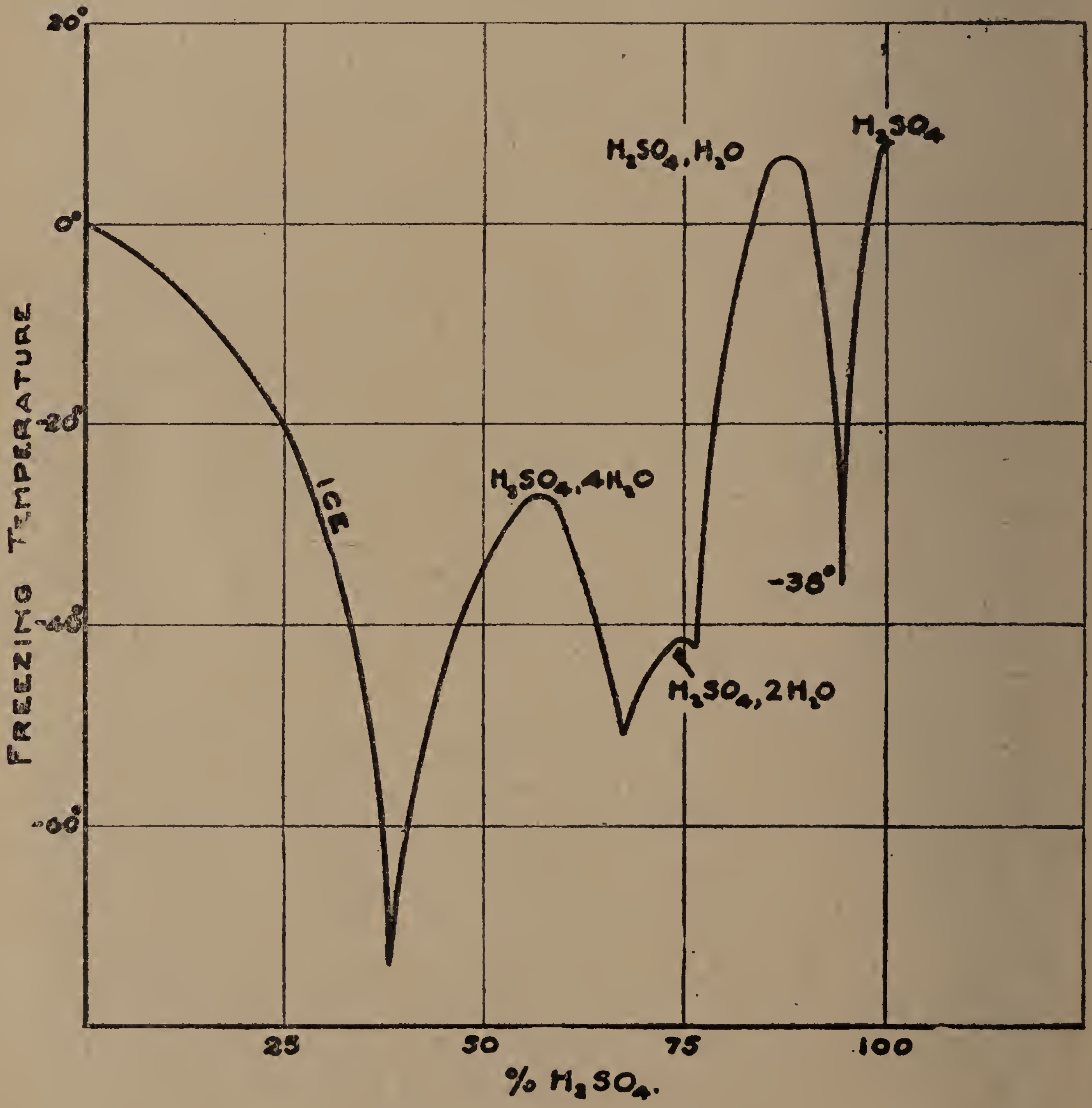
The specific gravities of sulphuric acid of approximately 60° and 66°Bé in both the liquid and solid states are given together with some observations on the supercooled acids.

Some years ago I was asked for an explanation of the destruction of a number of carboys of sulphuric acid. These were stored in the yard of an industrial plant, a custom followed for many years without loss, until the day before, when about fifteen were found broken, and the acid entirely lost. The temperature for a number of nights had fallen almost to zero, while the bright sun at mid-day warmed opaque objects to quite a high temperature.

My first impression was that the sulphuric acid expanded on freezing, and that the destruction of the carboys was due to this. A simple experiment showed that sulphuric acid between 60° and 66° Bé—the acid supplied varied in strength—behaved as a normal substance, being denser in the solid than in the liquid state. In attempting recently to make some more exact determinations of the density of the solid acid a number of the bulbs filled with the acid were broken. I shall give here some of the results obtained and a probable explanation for the failure of the carboys.

The specific gravity of the liquid acid was measured in the ordinary way in calibrated bulbs with graduated stems of capillary tubing. The bulb, containing a weighed amount of the acid, was kept in an appropriate constant temperature bath until its volume was constant. Sulphuric acid of any composition between 60° and 66° Bé could be kept in solid carbon dioxide almost indefinitely without crystallization taking place. When a crystal formed, or was introduced at this temperature, the growth of the solid was extremely slow. At a few degrees below the true freezing-point, these liquids froze rapidly, particularly on stirring. We have here a good example of a supercooled liquid.

The determination of the density of the solid is not easy, and the results can be looked on only as approximations. The sulphuric acid was frozen in the bulb with a calibrated stem, partially remelted, and this was repeated again and again, in order to fill, if possible, all interstices in the solid. (At times, the partly frozen mass was centrifuged). The bulb, completely filled with the solid acid, was placed in the constant temperature bath, and the total volume determined while the capillary



contained only liquid. From the specific gravity of the liquid which was known, that of the solid was calculated.

The results for approximately 60° and 66° Bé acids are given in the table.

60° Bé	Temp.	Sp. Gr.	66° Bé	Temp.	Sp. Gr.
Liquid	+15°	1.695		+20°	1.838
	—40°	1.756		—78.5°	1.951
	—78.5°	1.801			
Solid	—43°	1.797		—78.5°	2.040
	—60°	1.811			
	—78.5°	1.838			

As mentioned before, a number of bulbs were broken during the experiments, but always with rising temperatures. Apparently the solid sulphuric acid, in certain circumstances, adheres to the upper part of the bulb, and so prevents the free expansion of the liquid. This, I believe, furnishes a satisfactory explanation of the fracture of the carboys.

The diagram shows the freezing-points of sulphuric acid at various concentrations as given in the tables. In the transportation of acid in tank cars in winter, it might be possible to adjust the concentration at times, so that freezing would not take place thus avoiding the disagreeable task of melting the acid with a steam jet.

THE PREPARATION OF ANHYDROUS PINACOL.—By HAROLD S. KING, PH.D., and W. W. STEWART, Department of Chemistry, Dalhousie University, Halifax, N. S.

(Presented 12 May 1930).

ABSTRACT.

Anhydrous pinacol is best prepared from pinacol hydrate by distillation with benzene. The benzene in the distillate is freed from water in an automatic separator and syphoned back into the distilling flask. After the removal of water, the benzene is distilled off, leaving a residue of anhydrous pinacol. The yield is practically theoretical. This method is used for analyzing samples of pinacol hydrate for water content. Fractional distillation of pinacol hydrate without the addition of benzene gives a 75 to 80% yield, 20 to 15% being recoverable as hydrate by chilling the aqueous fraction of the distillate while 4 to 5% remains in solution and is lost. Dehydration in ether solution by means of calcium carbide gives a 90% yield of product possessing an objectionable odour. Treatment with anhydrous copper sulphate results in partial decomposition.

Anhydrous pinacol has been used as an intermediate in the manufacture of a synthetic rubber. Considering the importance of this application, little has been published concerning the preparation of pinacol though many methods of synthesizing its hydrate, which contains six molecules of water, have been devised.

Probably the most satisfactory method for preparing the hydrate is that of Holleman as modified by Adams and Adams[1]. A solution of mercuric chloride in a mixture of acetone and benzene is added to magnesium turnings. The magnesium pinacolate formed is decomposed into pinacol by the addition of the calculated quantity of water. After filtering, the pinacol is recovered as hydrate by a further addition of water. Before this second addition of water, fractional distillation of the benzene solution yields an unsatisfactory grade of pinacol. By converting the pinacol first to the crystalline hydrate, a yellow oil containing an unstable mercury derivative remains in benzene solution and is easily removed.

[1] Adams and Adams, *Organic Syntheses*, John Wiley and Sons, New York **1925**, vol. 5, pp. 87-9.

The water of crystallization is held only loosely since it is partly given off over concentrated sulphuric acid[2]. When distilled, the hydrate decomposes into water and pinacol which may be separated by fractional distillation[3]. Calvert[4] states that practically all the water is given off under 115°, ten to fifteen percent of the pinacol distilling with the steam and recoverable as hydrate. Fittig[5] dehydrated pinacol hydrate in ether solution with anhydrous calcium chloride. After filtering and distilling off the ether on a water bath, pinacol remained as a residue.

In our experiments three methods for the preparation of anhydrous pinacol were investigated. The first involved the use of calcium carbide as a dehydrating agent; the second was Linnemann's fractional distillation of the hydrate; the third was distillation with benzene until all water was removed and subsequent fractionation of the benzene-pinacol mixture. All three yielded anhydrous pinacol, but the yields and purity of product were most satisfactory in the third method.

Dehydration by Calcium Carbide.—Though calcium carbide has been used extensively for the removal of water of crystallization from various substances and for the dehydration of organic liquids[6], we have found no reference to its use in preparing anhydrous pinacol.

To 118g. of pure pinacol and 108g. of water in a liter flask fitted with a reflux condenser were added 700 cc. of ether and 250g. of coarsely powdered calcium carbide in 25g. portions. The flask was well cooled under the tap and shaken between

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2. Fittig, *Ann.*, **110,** 25(1859).
3. Linnemann, *Ann. Suppl.*, **3,** 375(1864).
4. Calvert, *India Rubber and Tire Review*, **26,** No. 9, 54(1926).
5. Fittig, *Ann.*, **114,** 56(1860).
6. In view of the fact that the carbide method has been proposed for the dehydration of ethyl alcohol [Yvon, *Compt. rend.*, **125**, 1181-2 (1897); Lyons and Smith, *Science*, **62**, 224-5 (1925).], it was decided to test this method with n-butyl alcohol. After refluxing for an hour with coarsely powdered calcium carbide, the alcohol was distilled off, refluxed with anhydrous copper sulphate and distilled again. This last distillation must be stopped some time before coming to dryness to prevent the evolution of sulphur dioxide. Evidently alcohol is oxidized by sulphuric acid liberated in the reaction between copper sulphate and acetylene. The yield (B.Pt. 117-118°) was only 80%. Though the product was of good odour, the method is not considered satisfactory.

additions. Much ether was lost during the evolution of acetylene. After standing over night, the flask was heated for an hour on a water bath and the contents filtered. The residue was washed with a liter of dry ether. This extraction was unusually efficient because of the porous nature of the filter cake. The combined filtrates were distilled in a flask fitted with a 3-foot fractionating column, the walls of which were indented to give more surface. The acetylene passed over with the ether. Everything up to 170°C. was collected in fraction A. Fraction B, 170-174°, was anhydrous pinacol and weighed 106g. Twenty-five cc. of water were added to fraction A and, on cooling in the ice box, 2g. of pinacol hydrate separated out. The residue in the apparatus was washed out with 25 cc. of water and from this solution 10g. of pinacol hydrate were recovered. Thus there was a 90% recovery of the pinacol in anhydrous form, 5% was in the form of hydrate and 5% lost in manipulation. The pinacol, however, had a faint odour resembling cacodyl oxide. It is possible that the carbide contained a trace of an arsenic derivative. A different batch of carbide gave a product with no such odour. It was thought that boiling the ether solution for an hour with anhydrous copper sulphate would remove the odour. It resulted in a further dehydration probably to pinacolone.

Dehydration by Fractional Distillation.—Pinacol hydrate, prepared by mixing 118g. of pure pinacol and 108g. of water in a round-bottomed flask fitted with the three-foot fractionating column previously described, was slowly distilled on an oil bath. Fraction A, distilling from 100° to 170°, weighed 124g. Practically all of this fraction came over below 102°, the rise to 170° being extremely rapid. At 170° a dry condenser was substituted for the one previously used and the fractionating column was wrapped with towels to facilitate the distillation. Fraction B, distilling at 170-174°, consisted of 93g. of anhydrous pinacol, which was practically odourless. After cooling, the apparatus was washed out with 50 cc. of warm water and the rinsings added to the residue in the distilling flask. Fraction A was chilled in the ice box and

27g. of pinacol hydrate (corresponding to 14g. pinacol) were recovered. From the residue there were likewise recovered 12g. of hydrate corresponding to 6g. of pinacol. Approximate solubility experiments showed that at 3°C. 100g. of water dissolved 3g. and at 6°, 3.5g. of hydrate. In the following calculations we assume that 100g. of water dissolved 3.5g. of hydrate.

Weight Fraction A =124g.
Pinacol recovered =14g.
Pinacol in solution = 2g.
Pinacol in A = 16g.
Water recovered =108g.

Pinacol recovered from A = 14 g.
Pinacol in B = 93 g.
Pinacol in residue = 6 g.
Pinacol in solutions = 2.5g.
Pinacol recovered =115.5g.

Thus we account for all of the water taken and all of the pinacol except 2.5g. The yield of anhydrous pinacol was79% of theoretical; the pinacol recovered as hydrate was 17% and 4% of the initial pinacol was lost. Another distillation of the solutions did not result in a recovery of any pinacol, so that a certain amount of pinacol is necessarily non-recoverable.

The percentages of pinacol obtained in anhydrous form vary in different experiments from 75 to 80, depending on the speed of distillation, and drop to 70 when the fractionating column is replaced by a simple still-head. Since nearly all of the water came over below 102°, our fractionating column must have been more efficient than that used by Calvert, who states that practically all the water is given off under 115°. Yet in no case was his 90% yield obtained.

Dehydration by Distillation with Benzene.—Pinacol hydrate, obtained from 118g. of pinacol and 108g. of water, together with 200cc. of benzene, was placed in a 3-necked, 1-liter, pyrex flask fitted (a) with the 3-foot, fractionating column leading to a condenser fitted with an adapor dipping below the surface of the liquid in an automatic separator, (b) with a capillary tube extending to the bottom of the flask for the introduction of air under pressure to prevent bumping, and (c) with a syphon from the automatic separator, through which the distilled benzene, after separation from the accompanying water, returned to the distilling flask. The mixture distilled at 68° until all the water was removed, when the temperature of distillation rose to 80°. The water fraction of the distillate was collected in a weighed flask and amounted to 108g., a 100% recovery. On cooling this water in the ice box, no pinacol hydrate separated out.

The anhydrous benzene solution of pinacol was poured into a weighed, 1-liter, pyrex flask. The first flask was rinsed out with benzene into the second. The 3-foot fractionating column was attached and the flask heated on a metal bath (Pb 50%, Sn 30% and Bi 20%). Distillation started at 79°. There were collected two fractions, A, boiling at 79-81°, and B, from 81° to 170°. The weight of the anhydrous pinacol remaining in the flask was 113g. or nearly 96% of the initial pinacol. Fraction A, consisting of nearly pure benzene, was shaken with 10 cc. of water, cooled in the ice box and seeded with pinacol hydrate. No crystals appeared. The apparatus was washed out with 50 cc. of water and the rinsings added to fraction B. From this solution 7g. of pinacol hydrate crystallized out. Allowing for 1.6g. of hydrate which remained in solution, this fraction contained 4.5g. of pinacol. Thus we account for all of the initial pinacol with the exception of half a gram. The crystallized hydrate and the aqueous solution were added to the next run and the pinacol recovered.

Though this method of dehydration is slow, it is automatic and requires little attention. The process was used in working up several gallons of dilute pinacol solution without interfering with other experiments. Practically the entire pinacol residue obtained in this way distilled between 170° and 174° to yield a water-white, almost odourless liquid which completely crystallized spontaneously to a nearly transparent solid.

It was thought that toluene might be substituted for benzene, but this was not successful, pinacol distilling over with toluene after the water had been removed.

Analysis of Pinacol Hydrate.—The results of the dehydration of pinacol hydrate by distillation with benzene were so nearly quantitative that the method was adopted for the analysis of pinacol hydrate. This pinacol hydrate was prepared by the method given by Adams and Adams[1] with minor modifications. One and one-half the quantities of material were used without increasing the size of the apparatus. By adding the water (350 cc. instead of 450 cc.) to the benzene solution of pinacol, obtained in the procedure, while it was still warm, and then cooling to 3° with occasional stirring and shaking, the crystals of hydrate were obtained in the form of a meal which filtered easily. The crystals were filtered by suction, washed with benzene, and exposed in a thin layer to the air of the laboratory for 24 hours. The yield was 553g.

The entire batch of pinacol hydrate was dehydrated by the benzene method already described. From the automatic separator 278g. of water were recovered. The yield of anhydrous pinacol was 273g. Since 1g. of pinacol was recovered from the 81-170° fraction and the rinsings of the apparatus, the total pinacol in the initial hydrate was 274g. The amount of material not accounted for was 1g. 274g. of pinacol corresponds to 525g. of hydrate, making the actual yield of pinacol hydrate obtained from 120g. of magnesium 47% of the theoretical amount. Since the water recovered weighed 278g. and the water combined in 525g. of hydrate is 251g., the excess water in the initial pinacol hydrate was 27g. In other words, the pinacol hydrate, after being sucked as dry as possible at the pump, washed with benzene and dried in the air for 24 hours, still contained 4.9% of uncombined water.

INVESTIGATIONS ON THE PROTOZOAN FISH PARASITES OF THE ST. ANDREW'S REGION.—MARJORIE F. ELLIS, B.A., Zoological Laboratory, Dalhousie University, Halifax, N.S.

(Presented 13 November 1929).

ABSTRACT.

The following myxosporidian parasites were found in marine fishes of the St. Andrew's, N. B., Canada, region: *Ceratomyxa acadiensis*; *Myxidium bergense*; *Leptotheca agilis* (new to the region); *Chloromyxum leydigi* (new to the region); *Ichthyophonus hoferi* (new to North America); *Goussia gadi*. The structure and habitat of these forms is described.

The Sporozoa are a group of endoparasites found in almost all sea fishes. In some cases they form conspicuous skin and muscular lesions, but more often they are free-living in the gall bladder and bile ducts of the host.

The trophozoites are generally amoeboid in form and motion. Some forms are attached to the epithelial lining of the cavity they inhabit. Within the class Sporozoa the Myxosporidia show great variation in size, form, structure, and mode of spore formation.

The spores are the agents for the infection of new hosts. Since the spore has a well-defined structure it is usually the chief means of identification. Where the spores are not obtainable identification is difficult and sometimes impossible.

In describing the reproduction of individuals and the infection of new hosts, Davis[1] uses the terms multiplicative reproduction and propagative reproduction. The former refers to the increase of the parasites within the host; the latter to the means by which it may infect a new host.

It is still uncertain exactly how multiplicative reproduction takes place in free living forms. Doflein[2] maintains that it is entirely the result of division of the plasmodia. Cohn[3] describes multiplicative reproduction taking place by exogenous budding. Davis[1] has given reasons for believing that the process as observed by Cohn is abnormal and he observed endogenous budding in the Myxosporidian, *Sinuolinea dimorpha*. In

[1] Davis—*Bull. U. S. Bur. Fish.*, **35**, 203 (1916).
[2] Doflein—*Lehrbuch der Protozoenkunde* 4th Ed. Fischer, Jena. 1916.
[3] Cohn—Cited by Davis.

tissue parasites multiplicative reproduction takes place by multiple division.

Propagative reproduction is by means of spores. In the case of free-living forms the spores pass out with the faeces, but in tissue parasites they usually reach the exterior only after the death and disintegration of the host tissue. Following this the spores depend on chance for the infection of new hosts. Infection, as far as can be ascertained, takes place through the digestive tract. The sporoplasm is extruded from the spore in the intestine of the new host and by moving along the lymphatic ducts, or by entering the blood stream, it finally reaches the body organ it is destined to inhabit.

The investigations reported here were carried on at the Atlantic Biological Station, St. Andrew's, N. B., during the summer of 1928. I am very grateful to the Biological Board of Canada for the courtesies extended to me and for the facilities provided for my work at St. Andrew's; also to Professor J. N. Gowanloch for his assistance.

Search for external and intra-muscular parasites, the presence of which would be shown by conspicuous dermal and muscular lesions, was carried on, as well as the study of the internal parasites infecting the gall bladder. Both fresh and stained preparations were studied. The material for the latter was fixed in Bouin's picro-formal solution and stained with Heidenhain's Iron Alum Haematoxylin and Orange G.

The following is a list of the species of fish examined:

68 flounder (*Pseudopleuronectes americanus, Walbaum*)
    11 gall bladders, 6 infected.

33 cod (*Gadus calarias, Linn.*)
    1 gall bladder, no infection.
    1 swim bladder, infected.

8 tomcod (*Microgadus tomcod, Walbaum*)
    8 gall bladders, no infection.

38 hake (*Urophycis tenuis, Mitchill*)
    12 gall bladders, all infected.

2 silver hake (*Merluccius bilinearis, Mitchill*)
    2 gall bladders, no infection.

15 haddock (*Melanogrammus aeglifinus, Linn.*)
11 gall bladders, all infected.

16 eel pout (*Zoarces anguillaris, Peck*)
3 gall bladders, 1 infected.

1 halibut (*Hippoglossus hippoglossus, Linn.*)
1 gall bladder, no infection.

3 sea raven (*Hemitripterus americanus, Gmelin*)
3 gall bladders, 1 infected.

13 mummichog (*Fundulus heteroclitus, Linn.*)
13 gall bladders, no infection.

6 rock eels (*Pholis gunnellus, Linn.*)
6 gall and 6 urinary bladders, no infection.

6 ghost fish (*Cryptacanthodes maculatus, Storer*)
6 gall bladders, 6 infected.

8 herring (*Clupea harengus, Linn.*)
8 gall bladders, 3 infected.

13 smelt (*Osmerus mordax, Mitchill*)
13 gall bladders, no infection.

5 barndoor skates (*Raja stabuliforis, Garman*)
2 gall bladders, no infection.

22 skate (*Raja erinacia, Mitchill*)
22 gall bladders, 13 infected.

Negative results followed an examination of blood smears from the following species in a search for protozoan blood parasites.—

Melanogrammus aeglifinis, Linn; *Zoarces anguillaris, Peck*; *Raja diaphenes, Mitchill*; *Raja stabuliforis, Garman*; *Raja scabrata, Garman*; *Gadus calarias, Linn*; *Squalus acanthias, Linn*; *Urophycis tenuis, Mitchill*; *Pseudopleuronectes americanus, Walbaum.*

LIST OF THE MYXOSPORIDIA FOUND.

1. *Ceratomyxa Acadiensis, Mavor.*

Trophozoite.—Club shaped with long slender tail. In fresh preparations ectoplasm distinguishable from endoplasm at anterior end. Trophozoites occur in clumps and attached to the epithelial wall of the gall bladder. Free swimming individuals move with rapid amoeboid motion. Length of vegetative trophozoites up to 40μ, width 5-10μ. *Spore.*—Bivalve, spindle shaped. Valves greatly elongated with very long slender lateral filaments whose total length can only be seen under favourable conditions. Polar capsules almost spherical and lie close to the sutural line. Width of spore 5-7μ. Length of spore, excluding lateral filaments 40-50μ. Diameter of polar capsules 3-4μ. Tri-radiate spores are of frequent occurrence. *Habitat.*—Gall bladders of the following fish: *Pseudopleuronectes americanus, Zoarces anguillaris, Urophycis tenuis.* Examination of fresh material from *Crytacanthodes maculatus* and *Clupea harengus* revealed large numbers of parasites tentatively as *Cearatomyxa acadiensis.*

2. *Myxidium Bergense, Auerbach.*

Trophozoite.—Rounded or longish. Occurs as free moving forms or attached to the epithelial lining of the gall bladder of the host. Ectoplasm clearly differentiated from endoplasm. The pseudopodia may be lobose, or fine and filiform for the attachment of the trophozoite. Diameter of trophozoite 30-50μ. Polysporous and monosporous. *Spore.*—Cylindrical. Slightly bent in the form of an "s". Capsules situated at the ends. Spore has a transparent envelope appearing under the microscope as a bright ring. Length of spore 16-19μ, width 8μ, length of polar capsules 4-5μ, width 2-3μ. *Habitat.*—Gall bladders of *Urophycis tenuis* and *Melanogrammus aeglifinus.*

3. *Leptotheca Agilis, Thelohan.*

Trophozoite.—Club shaped, terminated in a point at posterior end. Posterior end sometimes divided into several lobes. Anterior pseudopodia are long, filiform, hyaline, and difficult to see. Trophozoites swim rapidly. Length of trophozoite 50-80μ, width 15-20μ. Disporous. *Spore.*—Slightly elongated, sutural line distinct and at right angles to the longitudinal axis. Polar capsules distinct and placed on either side of the sutural line. Sporoplasm distinct, finely granular and nearly filling the valves. Length of spore 11-12μ, width 6-7μ, diameter of polar capsules 2-3μ. *Habitat.*—Gall bladder of *Raja erinacea.*

4. *Chloromyxum Leydigi, Leydigi.*

Trophozoite.—Elongated or oval in form when first placed on the slide, but soon became spherical in shape. Ectoplasm clearly distinguishable from endoplasm in young individuals which move with slow amoeboid motion. Endoplasm characterized by yellow or greenish globules. In sporulating individuals the differentiation between ectoplasm and endoplasm disappears and the movements of the trophozoites cease. Spore formation was observed to take place in an individual within three hours after removal from the host. Clear globules first appeared in the endoplasm within each of which a single spore developed. Diameter of trophozoite 15-18μ. Polysporous. *Spore.*—Ovoid and having a spore case characterized by large striae which give the posterior border of the shell a dentate appearance. Four polar capsules situated at the anterior end. Length of spore 10-12μ, width 8-10μ. Length of polar capsules 5μ, width 2μ. *Habitat.*—Abundant in the gall bladder of *Raja erinacea.*

5. *Goussia Gadi, Fiebiger.*

This parasite was found in the swim bladder of an emaciated cod, *Gadus calarias.* When opened the swim bladder was found to be filled with a white creamy mass. Microscopic examination showed many spores arranged in groups of four within a membrane, probably the remains of a host cell. Each spore contained two valves and the sporoplasm was very distinct. The form is reported by Mavor[4] from the air-bladder of *Melanogrammus aeglifinus.* Length of spore 12μ, width of spore 7μ.

6. *Unidentified Ceratomyxa.*

Trophozoites of this form were found in the gall bladder of *Hemitripterus americanus.* Although somewhat larger they closely resemble the trophozoites of *Ceratomyxa acadiensis*. No spores were present so identification of the species was impossible.

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[4] Mavor—*Contrib. Can. Biol.* **1911-1914**
Supplement 47th Ann. Rep. Dept. Mar. Fish. (1915)

One of the forms found, *Ichthyophonus hoferi* is, so far as can be ascertained, a new record for North America. *Chloromyxum leydigi* and *Leptotheca agilis* have not previously been reported from the St. Andrew's region.

In the course of the investigations carried on at St. Andrew's approximately 500 fish were examined and no instances of external lesions were found. This confirms the work of Mavor[4] in this region, and stands in contrast to the condition at Woods Hole, where such cases are fairly frequent in the same species of fish that were examined at St. Andrew's.

EXPLANTION OF FIGURES.

Ceratomyxa acadiensis.

Fig. 1. Group of trophozoites drawn from stained smear. X950.
Fig. 2. Spore without lateral filaments. X950.

Myxidium bergense.

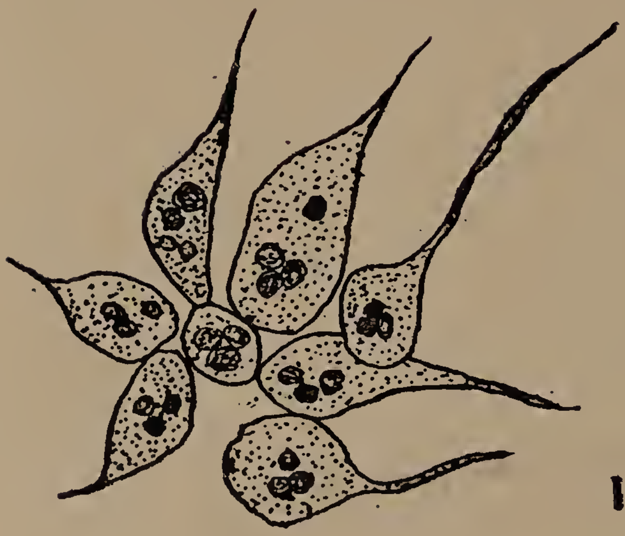
Fig. 3. Attached trophozoite drawn from section of wall of gall bladder of haddock. X950.
Fig. 4. Unattached trophozoite drawn from section. X950.
Fig. 5. Trophozoite showing filiform pseudopodia for attachment. X950.
Fig. 6. Spore of *Myxidium bergense*. X950.
Fig. 7. Unidentified trophozoite of *Ceratomyxa* from the gall bladder of *Hemitripterus americanus*. X950.

Leptotheca agilis.

Figs. 8. and 10. Trophozoites. X950.
Fig. 9. Spores. X950.

Chloromyxum leydigi.

Fig. 11. Sporulating trophozoite. X 440.
Fig. 12. Young trophozoite. X950.
Fig. 13. Trophozoite showing pseudopodia. X 440.
Fig. 15. Spore. X 950.
Fig. 16. Trophozoite showing clear spheres in which the spores develop. X950.



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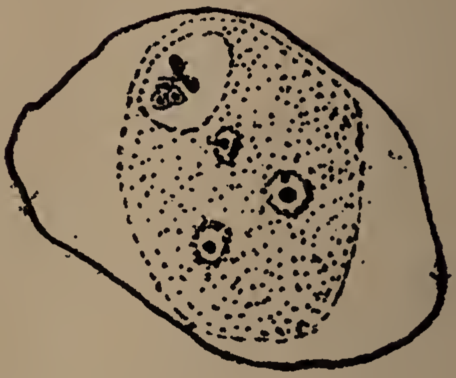

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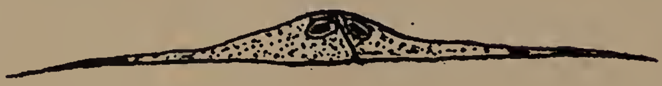

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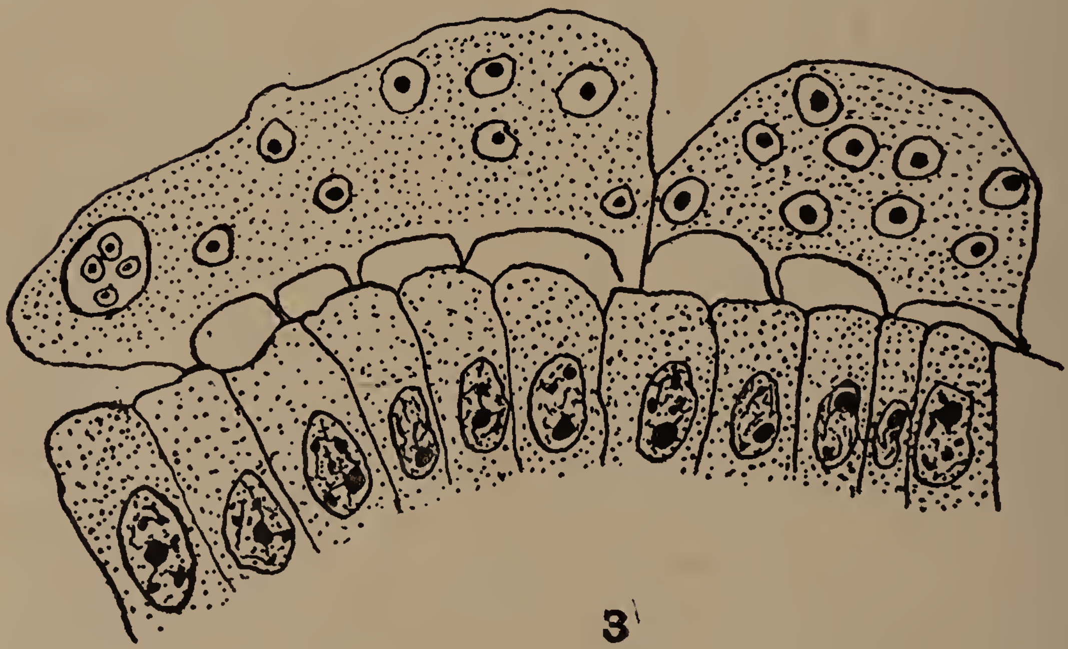

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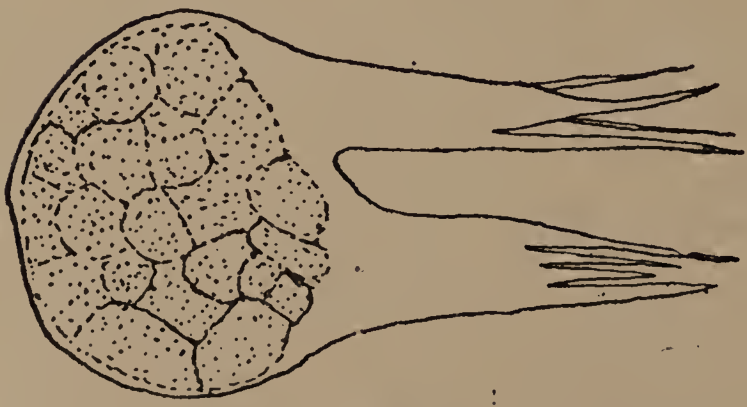

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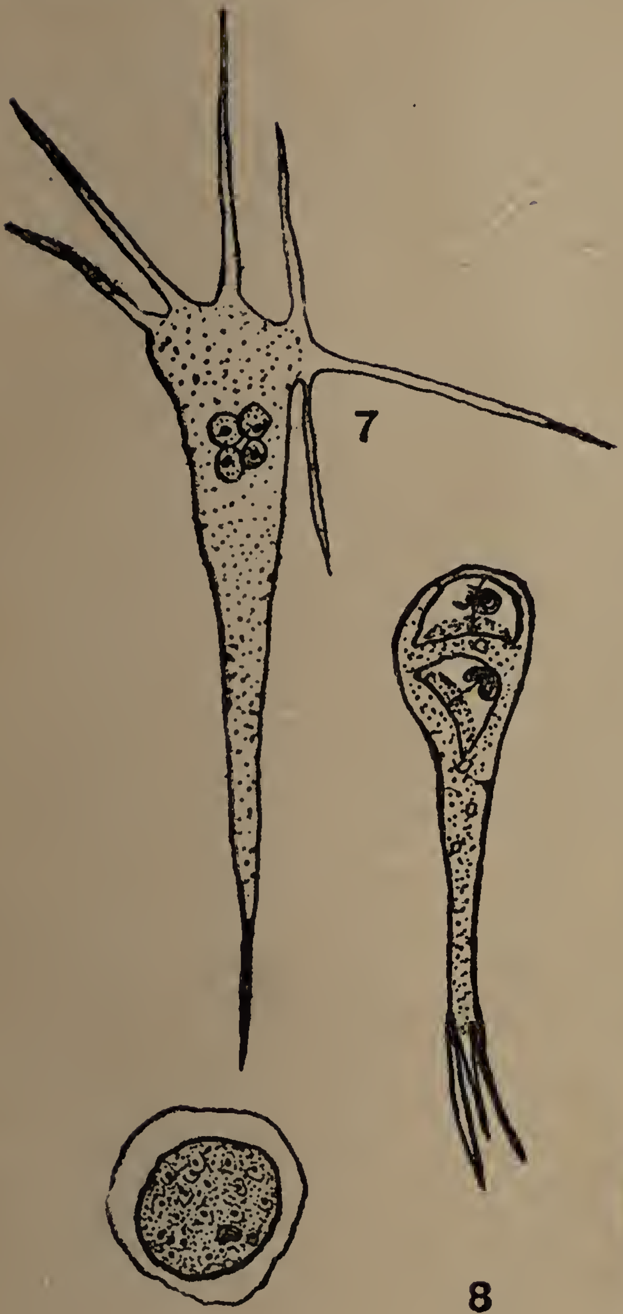

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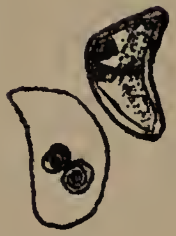

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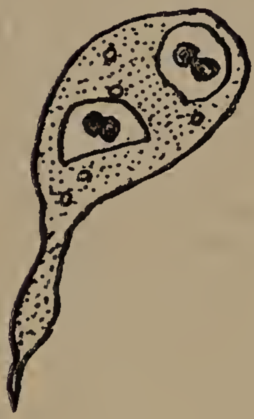

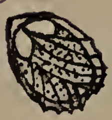

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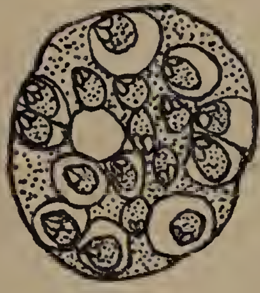

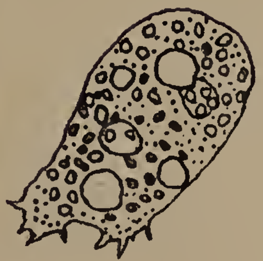

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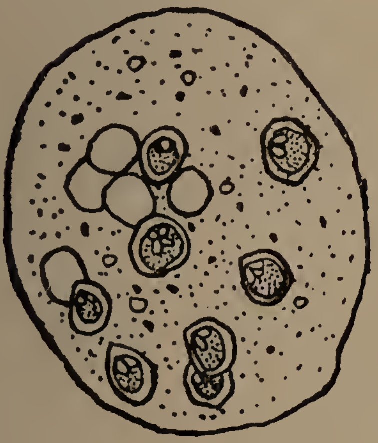

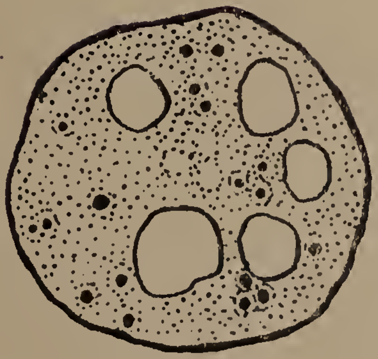

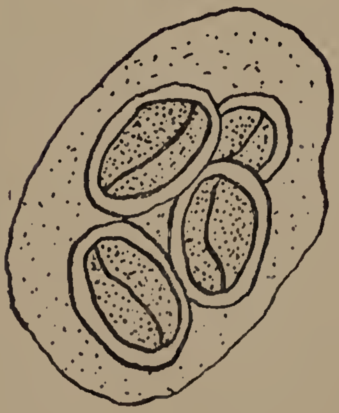

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